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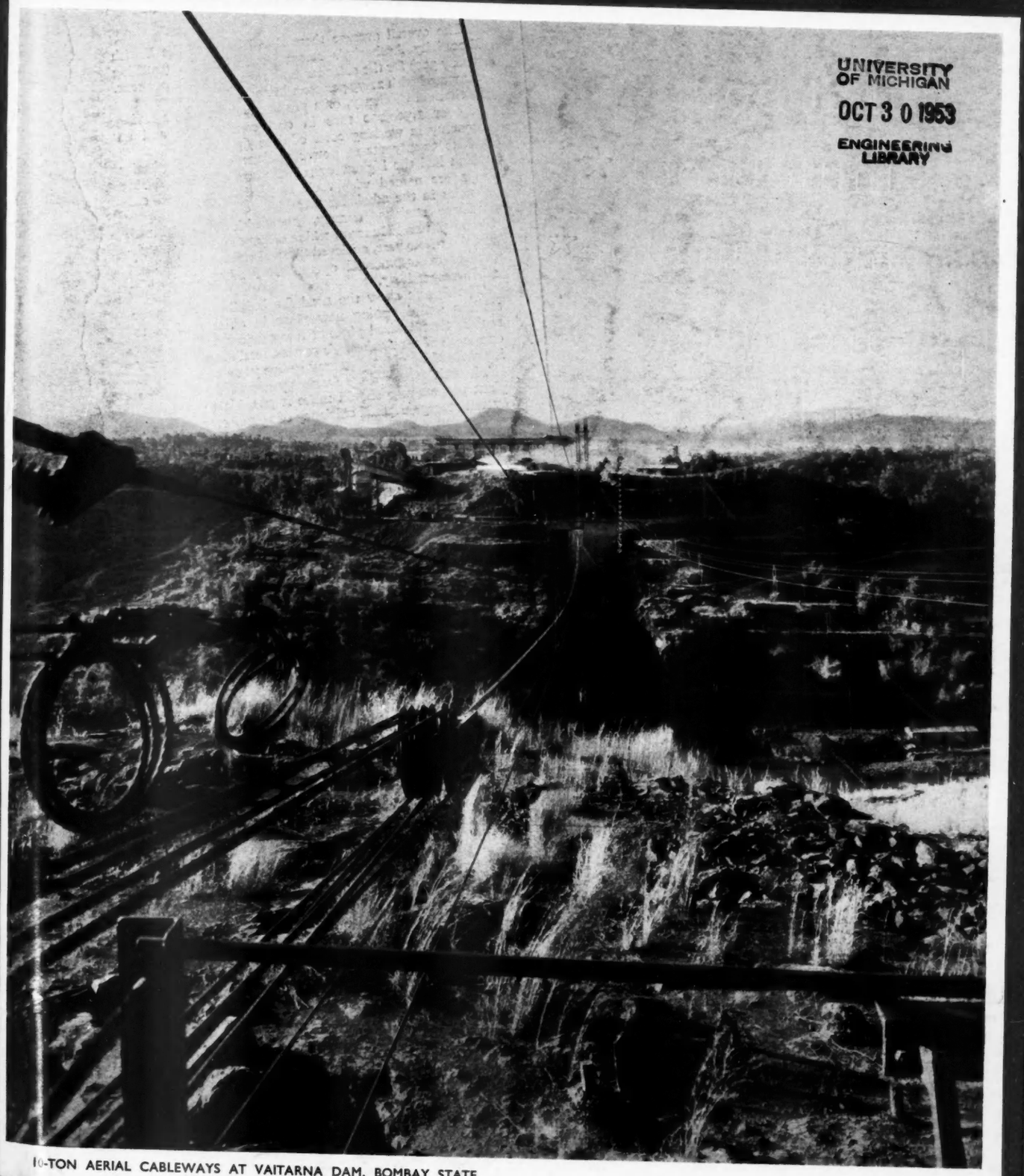

10-TON AERIAL CABLEWAYS AT VAITARNA DAM, BOMBAY STATE.

It is significant that both Littlebrook★ and Dunston★ are fitted with Lockheed hydraulic equipment

its delicacy permits the easy and precise control essential to high efficiency.

From the 'Engineering & Boiler House Review', May 1953

B.E.A. STEAM POWER STATION EFFICIENCIES

The overall average thermal efficiency of the British Electricity Authority's steam power stations (totalling nearly 300) for the calendar year 1952 was 22.61 per cent. compared with 21.79 per cent. in 1951. The improvement in thermal efficiency, 0.82 per cent., represents a saving of over 1,300,000 tons in coal consumption and an economy in working costs of over £3,000,000.

The twenty steam power stations of the Authority which had the highest overall thermal efficiency during 1952 are named with their respective individual efficiencies in the adjoining table.

Three stations, namely, Brunswick Wharf, North Tees "C" and Huncoat, which did not operate throughout the whole year, achieved thermal efficiencies for their periods of commercial operation of 28.41, 26.93, and 26.60 respectively.

The figures show the need for building new power stations and installing new plant in older stations to replace time-expired plant of low efficiency. Well over one-tenth of the Authority's present total output capacity is provided by plant over twenty-five years old.

The British Electricity Authority states that its present plant programmes should make it possible to reach an overall average thermal efficiency of 26 per cent. in 1960.

Station	Thermal efficiency per cent.
★ Littlebrook "B," Dartford, Kent	29.95★
★ Dunston "B" II, Newcastle-upon-Tyne	29.65★
Portobello H.P., Edinburgh	29.46
Skelton Grange, Leeds	29.19
Bromborough, Cheshire	28.88
Stourport "B," Worcs.	28.84
Battersea "B," London	28.71
Poole, Dorset	28.31
Braehead, Renfrew	27.79
Agecroft H.P., Salford	27.20
Blackwall Point, London	26.66
Clyde's Mill H.P., Glasgow	26.66
Fulham, London	26.63
Cliff Quay, Ipswich	26.63
Stuart Street H.P., Manchester	26.47
Brimsdown "B," H.P., near Enfield	26.41
Hams Hall "B," near Birmingham	26.24
Llynfi, near Bridgend, South Wales	26.23
Staythorpe, Newark	26.18
Croydon "B," Surrey	26.02

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AUTOMOTIVE PRODUCTS COMPANY LTD., LEAMINGTON SPA

ALUMINIUM-ALLOY BASCULE BRIDGE AT ABERDEEN.

On Wednesday, September 30, Her Majesty Queen Elizabeth the Queen Mother formally opened the new bridges at the entrance to the Victoria Dock, Aberdeen, and named them St. Clement's Bridges. The bridges are illustrated in Fig. 1 below. They consist of the bascule bridge with aluminium alloys in the moving spans and of the removable steel bridge shown on the right of the illustration. Although of no great size, the bascule bridge, of unorthodox design, is of an entirely new type and it is the first bascule bridge in Scotland for which aluminium alloys have been used for the construction of the principal members. Novel methods of fabrication, of operation and of counterbalancing have been used, and the design is the subject of a patent by Mr. John Anderson, M.I.C.E., Engineer to the Aberdeen Harbour Commission.

The bridges form a modern traffic link from north to south across the sea entrance to the Victoria Dock, and they also provide an alternative road connection to the new nearby deep-water berth, thereby assisting in the rapid turn-round of shipping, simultaneously relieving road congestion elsewhere. The opening ceremony marked the completion of the first stage of the long-term plans of the Aberdeen Harbour Commission for the development of the port, which will include a new fish basin, a new freight dock, extensions to the piers and breakwaters, widening of existing quays and a new tidal-lock entrance to the port as a whole. Since the war, nearly 1,000,000*l.* has been spent on the new deep-water berth already referred to, a coaling installation and the new bridges.

The harbour engineer had a number of problems to face before deciding on the types of bridges to be adopted. For example, as can be seen from the right foreground of Fig. 1, the north lock is now permanently sealed at its seaward end, because of the poor condition of the lock gates, by a concrete dam, and all sea traffic has to use the south lock now crossed by the new bascule bridge. The north lock is now used, however, as a repair berth where vessels are refitted with engines and boilers, which are slung into position from large permanent shear-legs that are nearby. In order to make this refitting berth available to large vessels requiring the full length of the lock, the new bridge spanning the 57-ft. wide lock has been made removable. The simple steel-decked span can be raised from its abutments by lifting it on a pontoon built from 14 "beetles" which were previously used to support a floating roadway in the Mulberry Harbour installations during the Allies' invasion of the Continent. Removing this bridge does, of course, close the road that has been made available by constructing the bridges, but this had to be balanced against the added repair facilities that were achieved.

Additional problems arose when dealing with the type of movable bridge for the south entrance to the Victoria Dock, which is the principal commercial dock and communicates with the Upper Dock. The construction of a new movable bridge could not be allowed to interfere with the passage of shipping through the dock; the limited space available at the site dictated that the bridge should occupy the minimum ground space; concentrations of weights had to be reduced to a minimum so that the foundation costs could be kept low; the bridge had to be speedy in operation and driven by simple machinery with low operating costs; if possible, it should present a pleasing appearance and should be immune from damage by shipping when in the fully open position. In order to meet all these requirements, Mr. John Anderson developed this new type of double-leaf heel-trunnion bridge employing aluminium alloys in the moving spans. Each leaf rotates about a trunnion at the landward end, the trunnions being set at 100-ft. centres.

The contract for the design, construction and erection of the new bridges was entrusted to Head, Wrightson and Company, Limited, Teesdale Iron Works, Thornaby-on-Tees, whose subsidiary aluminium company have had a wide experience in the design and fabrication of the heavier type of aluminium-alloy structures. It may be recalled that in 1948 the company built the first aluminium-alloy bascule bridge in the world, at the entrance to the Hendon Docks, Sunderland.

The Bascule Bridge.

Structural Details.—The bridge is a double-leaf trunnion-mounted bascule type designed to carry both road and rail traffic; Fig. 2, on page 482, is an elevation of one principal truss and one shore structure, and Fig. 3, a half plan of the bridge. A 22-ft. roadway has been provided between the trusses, with walkways 5 ft. wide outside the trusses to cope with peak-hour pedestrian traffic. The principal dimensions of the bridge are: clear opening to the dock, 70 ft. 0 in.; span between the centre-lines of the trunnions, 100 ft. 0 in.; overall length of moving span, 69 ft. 11½ in.; approximate overall length of the bridge, 198 ft.; longitudinal camber of the bridge, 4½ in. between trunnion centres; clear height under the machinery portal (limiting clearance for traffic), 16 ft. 0 in.; angle of opening of the bridge, 87 deg.; overall width, 37 ft. 1 in.; and centre to centre of the trusses of the moving spans, 25 ft. 0 in. The total weight of aluminium alloy used in the movable spans is 48 tons.

The flooring system, indicated in Fig. 3, on page 482, is of cross-girders supporting troughing, the wells of which have been left unfilled. Across the tops of the troughs and bolted down are underlay timbers of Rhodesian teak, which are 3 inches thick, tongued and grooved and laid diagonally. The rails, set at standard gauge and crossing the bridge towards one side, have been bolted through the teak underlay to the tops of the troughing. The road surfacing of the bridge is made up to the level of the heads of the rails by dowelled paving blocks of Douglas fir, 5½ in. thick, coach-screwed to the teak underlay. In all, about 25½ tons of timber have been used in the bridge deck; it was supplied, prepared, shipped to the site and laid by the Acme Flooring and Paving Company (1904), Limited, River-road, Barking, Essex.

The maximum load for which the bridge is designed is that specified in B.S.153, for a highway load of 15 units plus an allowance of 50 per cent. for impact, together with a rail load consisting of an "Austerity"-type shunting locomotive having an all-up weight of 48 tons 3 cwt. 3 qr., followed by a train with 16-ton axle loads at 10-ft. centres, with an impact allowance of 20 per cent. The allowed footway loading is 84 lb. per square foot. The bridge has been designed for two lanes of road traffic or one line of road traffic and one line of rail vehicles.

The aluminium-alloy plates and extruded sections

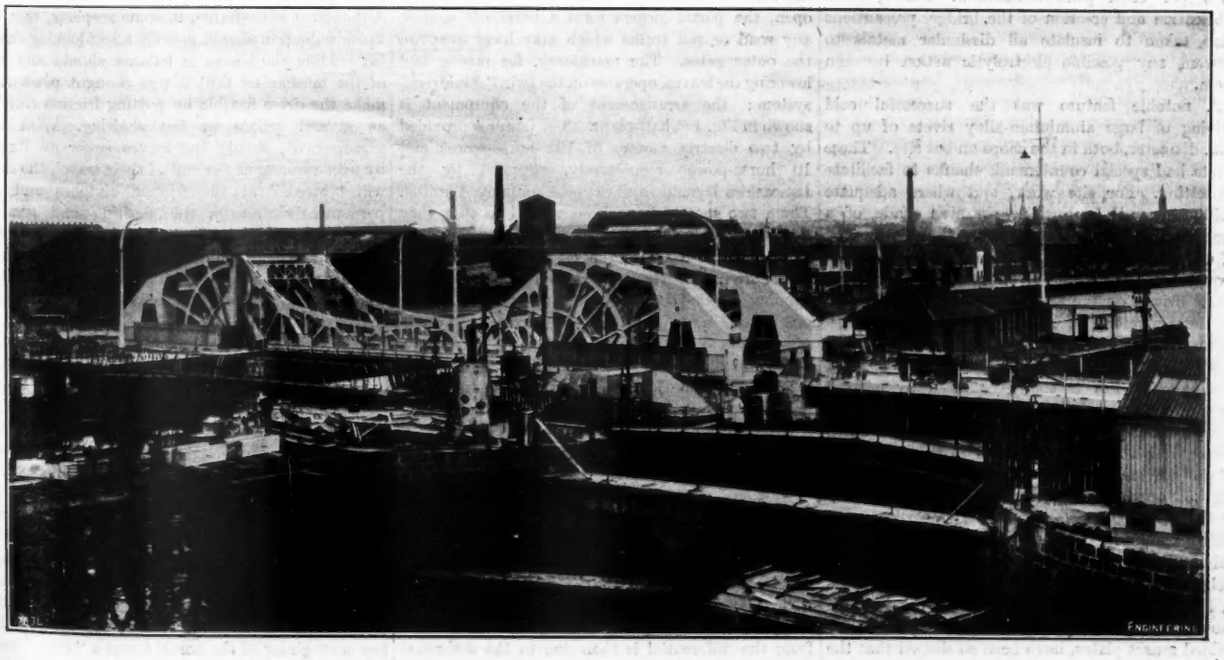


Fig. 1. Aluminium-Alloy Bascule Bridge and Removable Steel Bridge.

ALUMINIUM-ALLOY BASCULE BRIDGE AT ABERDEEN.

Fig. 2. HALF ELEVATION.

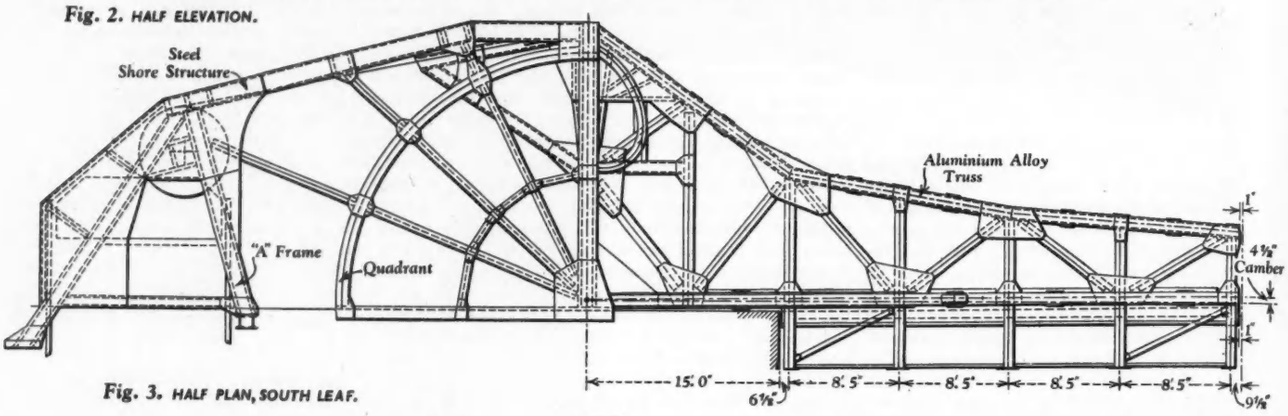
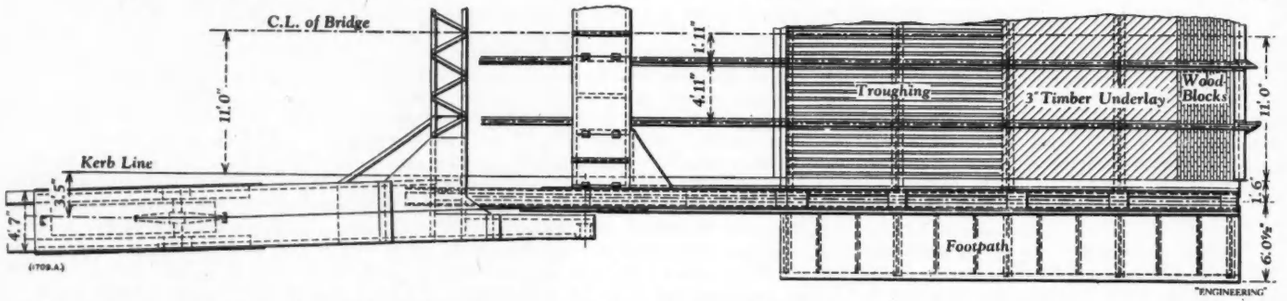


Fig. 3. HALF PLAN, SOUTH LEAF.



for the bridge were supplied by the British Aluminium Company, Limited, Norfolk House, St. James's-square, London, S.W.1, and by the Northern Aluminium Company, Limited, Banbury, Oxfordshire. Two types of alloy were used: an aluminium-copper-manganese-magnesium alloy for the flooring system and an aluminium-magnesium-silicon alloy for the main trusses and the portal structure containing the operating machinery. These two sets of alloys are specified in B.S.1470, where details are given of their mechanical properties. To ensure maximum protection against the acid-bearing teak underlay, the whole of the flooring system has been metal-sprayed with a 99·5 per cent. pure aluminium. During both fabrication and erection of the bridge, precautions were taken to insulate all dissimilar metals to prevent any possible electrolytic action between them.

A notable feature was the successful cold driving of large aluminium-alloy rivets of up to ⅞ in. diameter, both in the shops and at site. These rivets had special countersunk shanks to facilitate up-setting. For site work, and where adequate holding proved impossible, use was made of a grummet or ring which was placed over the tail of the rivet, so reducing the amount of distortion required to complete the riveting. Test pieces from rivets driven on the site were subsequently tested at the University of Aberdeen with highly satisfactory results.

Method of Counterbalance.—The dead weight of each moving leaf is counterbalanced by a fixed weight contained in a welded steel box hanging from a locked-coil rope of 1¾-in. diameter, which passes over a special cam bolted to the main truss of the moving leaf; the arrangement is shown in Fig. 5, opposite. The rope has been anchored to the trusses by a special socket, shown in Fig. 6, which allows for adjustment of the rope. Each balance box weighs approximately 24 tons, the weight being made up of cast-iron blocks bedded in lead. The cams, which have the cross-section shown in Fig. 7, opposite, and strengthened by welded gusset plates, have been so shaped that the lever arm of the counterbalance pull is varied so that the leaves are underbalanced when in the lowered position, just balanced when they are being raised or lowered and overbalanced, to give greater stability, when in the raised position. There are two counterbalance weights to each leaf, one to each truss, and running into pits at the rear of the mass-concrete foundations. Above the pits, steel A-frames (part of the shore structure, described below) carry 7 ft. 6 in. diameter pulley wheels over which the counterbalance-weight ropes pass, to be redirected on to the cam.

Operating Machinery.—All the operating machinery is housed within the aluminium-alloy portal girder, about 5 ft. square, which forms part of the moving-leaf structure. When the bridge is fully open, the portal girders form a barricade against any road or rail traffic which may have over-run the outer gates. The machinery, for raising and lowering the leaves, operates on the twin "Fluidrive" system; the arrangement of the equipment is shown in Fig. 4 (a half-plan). The power is provided by two electric motors of 13½ horse-power and 10 horse-power respectively, supplied by the Lancashire Dynamo and Crypto Company, Limited. These two motors have been wound so that they develop equal torques and they therefore run at speeds which are in the ratio of four to three. The current for the motors is carried in cables running inside the bridge framing and leading on to the moving leaf at the trunnions where movements are relatively small. Both the motors, which are on a common centre-line, drive through fluid clutches, made by the Fluidrive Engineering Company, Limited, Worton-road, Isleworth, Middlesex, on to the two sides of a common differential. When the leaves begin to move from rest the drive is provided initially by only the larger of the two motors; very quickly the second motor is brought into operation, driving in the same direction as the first, so that the speed of motion is increased in the ratio from four to seven. As the leaves approach within 3 deg. of the end of their travel, the second motor is first cut-out, stopped and then reversed; thus, the output drive from the differential is then due to the difference in speed between the two motors, that is, one-seventh of the maximum speed. In this way, the momentum of the leaves is reduced to minimise the danger of impact should the mechanism over-run. In the event of a failure, either motor is capable of moving the bridge.

From the differential, the drive is passed through a worm gear which reduces the speed by thirty to one. From the wormwheel the drive is carried outwards to the sides of the bridge and through a simple spur reduction to the driving pinions mounted outside the main trusses. The driving pinions mesh with steel pin-type rack quadrants fixed to the shore structure; the racks consist of 78 steel pins accurately mounted on a curved plate to give an effective pitch radius of 19 ft. Although it is desirable, in some respects, that the worm reduction should provide a self-locking device (so holding the leaves in balance should any part of the mechanism fail) it was thought prudent to make the drive flexible by putting friction clutches at several points in the shafting. With this arrangement, should the leaves suffer an impact by over-running at the end of their travel, the drive will "break" at the friction clutches and not permanently damage the shafting and gearing. All the gearing, the differential, the worm-gear and spur-gear reduction units together with the working pinions were made by Crofts (Engineers), Limited, Thornbury, Bradford. If necessary—for example, in the case of a power failure—the drive can be broken, and be hand operated; raising or lowering each leaf would then take about 30 minutes.

The Shore Structures.—On each bank there is a fixed shore structure of steel. To the rear of each of these structures are the A-frames which support the counterbalance-weight pulleys; as can be seen from Fig. 1, on page 481, the A-frames have been covered with sheeting. The middle section of the structure provides a framing which carries the rack quadrant of the operating machinery. The front of the shore structure is a portal frame which incorporates the trunnions at the foot of the columns and the top of which is tied back through the structure framing to the rear of the bridge. The top cross girder of the portal forms a "stop" beam providing the reaction which, with the horizontal

ALUMINIUM-ALLOY BASCULE BRIDGE AT ABERDEEN.

Fig. 4. OPERATING MACHINERY.

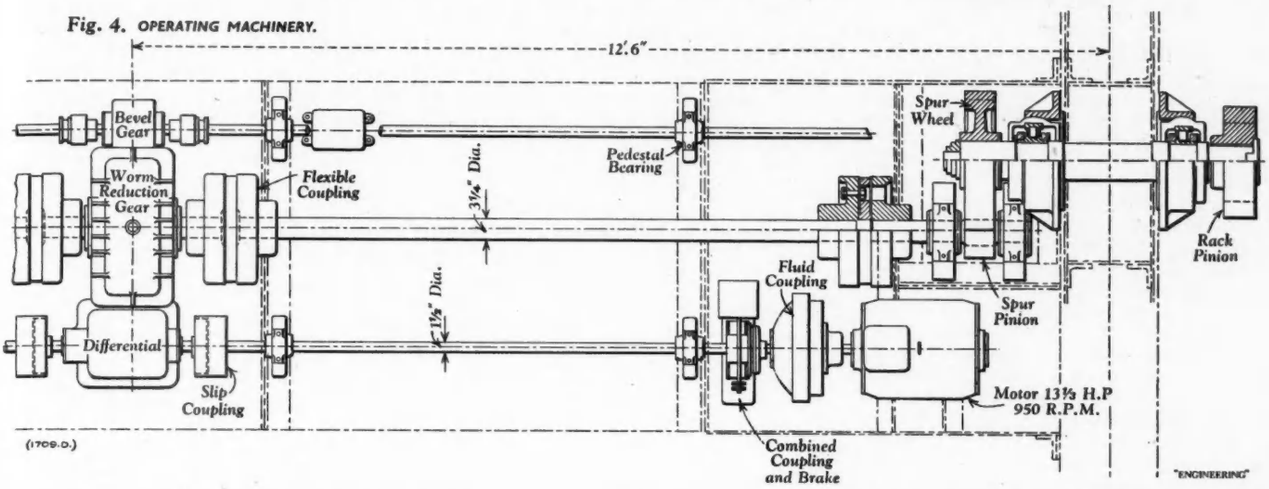


Fig. 5. GENERAL ARRANGEMENT OF COUNTERBALANCE.

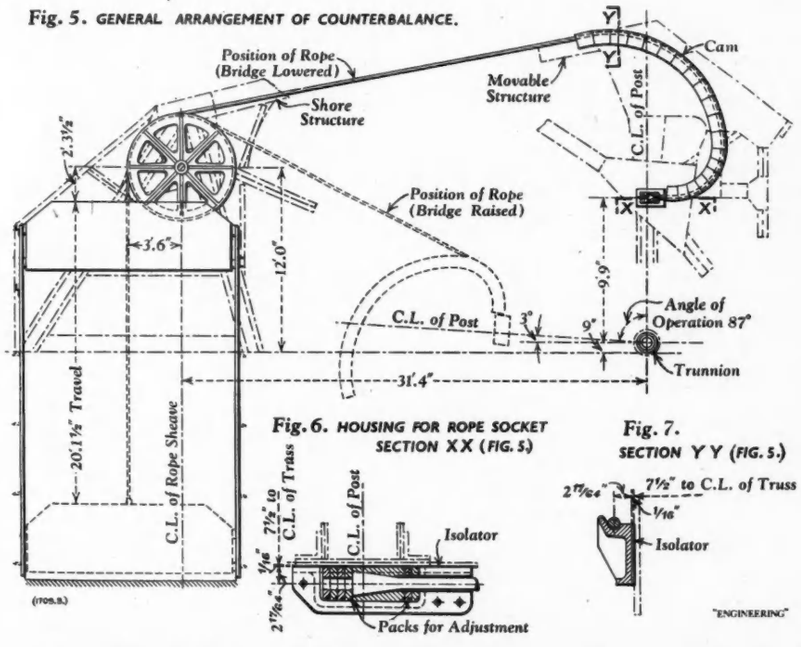


Fig. 6. HOUSING FOR ROPE SOCKET SECTION XX (FIG. 5.)

Fig. 7. SECTION Y Y (FIG. 5.)

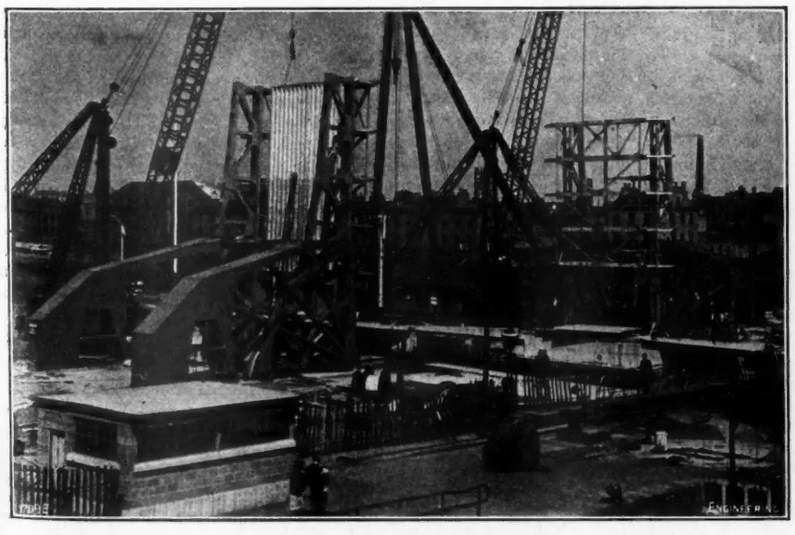


FIG. 8. BRIDGE UNDER CONSTRUCTION.

reaction at the trunnion, provides the resisting couple to the live-load bending moment. The horizontal reaction at the stop beam is carried by buffers which work against pads at the top of the rear posts of the leaf trusses. Thus, a consideration of the forces involved shows that, at the trunnion, there are vertical and horizontal reactions due to both the dead and the live loads and that the active horizontal thrust is directed into the mass of the quay wall. The second set of forces, required to complete the reaction couples, are provided by the counterbalance weight, which opposes the dead load only, and the holding-down bolts at the rear of the shore structures balancing the live load. Thus it has been possible to minimise the loads and stresses imposed on the front of the quay wall; the trunnions are located 15 ft. behind the quay face.

Control Mechanism.—The bridge operator may control the bridge from either the control house, to be seen on the left of Fig. 1, on the south approach to the bridge, or from a remote-control panel located on the other side of the dock entrance. The electrical equipment has been so arranged that the bridge is controlled from a master-drum controller and successive movements are introduced, once the mechanism has been set in motion, by a system of limit switches and operating relays. Luminous indicators show the position of the bridge leaves, and interlocks ensure that the electrical operation is foolproof. Navigation lights for shipping and traffic lights for road and rail vehicles protect the bridge from damage.

Centre-Lock Machinery.—When in the down position, the leaves are locked to each other by two steel bolts which ensure that the leaves deflect together as a load passes over the bridge. The bolts are driven home by a motor mounted under one leaf; the motor, together with the transmission gears, have been so fixed that they may be removed *en bloc* from their working position for maintenance or replacement with the minimum of interference to the bridge. This motor is operated from the master-drum controller through a limit switch actuated when the leaves mate.

Erection and Construction.—The preparation of the quay walls and of the foundations for the bridges, together with some other local extension of the quay walls, was undertaken by William Tawse, Limited, Angusfield, Aberdeen. The steel shore structures were put into position first and subsequently the moving spans were erected in 90 days. The lightness of the aluminium sections allowed large sub-assemblies to be shipped directly to site and heavy cranes were not required for erection purposes. Fig. 8, herewith, shows the bridge under construction.

LITERATURE.

The Electrical Manufacturers, 1875-1900.

By Harold C. Passer. Harvard University Press, Cambridge 38, Massachusetts, U.S.A. [Price 6 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 40*s.* net.]

The first thing that must be said about this book is that, as far as British readers are concerned, the title is misleading. It is concerned entirely with the American scene; and the part played by pioneers elsewhere is mentioned only in so far as their work affected development in that country. In the second place it is not, as the author himself explains, a technical history; neither is it an economic history in the traditional sense. "Four problems serve to focus the material and have received major attention: entrepreneurship, competition, technical change and economic growth." In the third place Mr. Passer, as a student at Harvard, came under the influence of the late Professor J. A. Schumpeter, who "had a particular interest in forces that brought major changes in the economy and an interest in the manner whereby technological innovations became effective in business"—and this book may be described both as a thesis on, and as a tribute to, his memory.

After a short introduction on the American economy prior to and during the 25 years under review, a period that was favourable to manufacturing generally and to the electrical manufacturing industry in particular, the author goes on to deal with the latter in detail under the headings of Arc Lighting, Incandescent Lighting and Electric Power, including traction, a study which occupies most of the book. Each part begins with a section entitled The Setting, which contains a succinct historical account of the equipment which is to be dealt with later. In the section on arc lighting this is followed by a description of the rise of the leading manufacturing firms and their relationship with each other. This relationship was competitive rather than friendly, particularly when it came to dealing with the patents which loomed so largely in their activities. The development of this type of lighting and the equipment used are also described. Incandescent lighting receives similar treatment where that is felt appropriate, though here the descriptions are dominated by the doings of Edison. Edison appears again, if in a less important role, in the chapter on electric power, F. J. Sprague and George Westinghouse taking his place as the principal protagonists. In all cases much space is devoted to the financial struggles of the early manufacturing firms, struggles which culminated in the virtual domination of two—the Thomson-Houston (now the American General Electric) and the Westinghouse concerns. The author summarises the position by pointing out that: "The existence of only two full-time producers after more than two decades of growth was largely the result of patents." The information given by Mr. Passer definitely supports this conclusion, and perhaps for that reason ethically leaves much to be desired.

The book itself does not make easy reading, although it is clear from the bibliography that the author has been given facilities to consult original sources; and factually, therefore, his information may be regarded as correct. His style is, however, heavy and he does not always resist the temptation to use words like "oligopoly" and "duopolistic" (trusting to the context to reveal their meaning), or to employ verbosity instead of succinctness. In fact, he seems to have written down all, or nearly all, he can discover about his subject, as viewed from the particular standpoint in which he is interested. The result is that the important and the irrevelant both find a place and tend to become inextricably intermingled. Condensation would therefore have been advisable. The electrical manufacturing industry has, of course, developed enormously since 1900, not only in the United States but in this country also. The result is that there has been a shift of emphasis during the intervening period which reduces the value of much of what Mr. Passer has to say. Nevertheless, this work will be an excellent source book for the author of that authoritative history of electrical engineering which still remains to be written, especially as it contains a wealth of statistical data and a really excellent bibliography.

Facts, Files and Action in Business and Public Affairs. Part 2. Filing, Indexing, and Circulation.

By J. Edwin Holmstrom, Ph.D. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 32*s.* net.]

The word "triad" has a number of meanings; one is "a group or set of three things, words, attributes, collectively or in connection." When Dr. Holmstrom set out to compile a treatise dealing with the ambitious subject of "the art of getting things done," he decided that the necessary activity had three main stages. These were: collecting the necessary information and data on which action was to be taken; organising this material in order to render it accessible and usable; and acting on it. This volume is the second limb of the triad. The first, of which the subtitle was *Sources and Backgrounds of Facts*, was reviewed in our issue of December 21, 1951, page 771. The third part, which has yet to appear, will deal with action.

Although the three parts of the triad will exist "collectively or in connection," the two now available are not interdependent to the extent that they may not be used independently. The present volume, the subject of which is adequately covered by its subtitle, is to a considerable extent concerned with machinery. That is the actual appliances necessary for any filing system worthy to be called a system. With characteristic thoroughness, Dr. Holmstrom describes the whole range of appliances available from the simplest to the most complicated. A feature of the book which will be of much value to anyone introducing, revising or extending a filing system, is that the names of the makers and the prices of most pieces of apparatus are given. This is much better than the all too common practice of describing appliances in general terms, leaving it to readers to find the names of firms and consult numerous catalogues and leaflets before they can obtain an overall view of what is available. Dr. Holmstrom has carried out this laborious inquiry for his readers. The information given is not confined to filing methods: indexing, sorting, and document-reproducing appliances are dealt with.

The above remarks must not be taken to indicate that this volume is a sort of handbook to office appliances. It may reasonably be described as a philosophical treatise on the subject of collecting and organising information. On indexing systems, for example, which are fully dealt with, the suitability of different methods for different ends is discussed. Dr. Holmstrom is sceptical about straining the Universal Decimal Classification, which has so many "impassioned supporters," to minute subdivisions in specialised fields. Many of those who are concerned intensively with a highly specific branch of work will agree with this. He also points out what the impassioned supporters are apt to overlook, that "it is not in fact the case that independent classifiers will always give the same item exactly the same class number."

It is not intended to suggest that the book contains an attack on the Universal Decimal Classification. The point is that all systems have their particular advantages and disadvantages; that which is suitable for a library, in which the units dealt with are books, may not suit the requirements of an information department which is mainly concerned with periodicals and individual articles in periodicals. Not much is said about libraries, which are not the subject of the book; it is concerned with the information that is collected and circulated for use by its workers in a research establishment or a business firm. A difficult matter, which is discussed with clarity and understanding, is the method, or methods, of dealing with correspondence from outside; this may frequently contain matter of technical or business importance which should in some way be brought to the attention of scientific or operative workers who are not concerned with, and should not be distracted by, day-to-day business correspondence.

Les Diagrammes Enthalpie-Entropie: Applications à l'Air et aux Gaz de Combustion.

By Dr. P. Chambadal. Dunod, 92, Rue Bonaparte, Paris (6e). [Price 940 francs.]

The advent of the gas turbine, employing a working substance that is neither homogeneous nor a mixture of fixed composition, and extending the limits of operation of the thermodynamic cycle, requires new and revised data to permit its performance to be calculated accurately and expeditiously. The three diagrams presented here have been designed to enable such calculations to be effected from numbers read directly from them. Each diagram relates primarily to one of the main components of a gas turbine—the air compressor, the combustion chamber and the turbine proper—but can also be made to apply to air coolers and heat exchangers. The numerical data from which the diagrams have been prepared were selected and adapted from Keenan and Kaye's *Gas Tables* (1948). Details concerning their mode of construction, together with examples illustrating their use and descriptive material relating to gas-turbine theory, combustion processes, etc., are contained in the accompanying 50-page booklet.

Diagram I is an enthalpy-entropy chart for 1 kg. of air. Since the enthalpy depends only on the temperature, a scale of temperature from 0 to 320 deg. C. is also marked along the ordinate axis. On the diagram is traced, in black, a network of isobars corresponding to pressures from 0·1 to 10 kg.-cm.$^{-2}$, and, in red, a network of isochores corresponding to specific volumes between 0·16 and 12 m^{3}kg.$^{-1}$, and from it the state of the air on emerging from the compressor can be completely determined. Diagram II serves for the determination of the weight of fuel per kilogram of air, the ratio (r) of the weight of air theoretically needed for combustion to that actually used, the molecular weight of the fuel, the resulting heat developed in terms of the lower calorific value of the fuel, its hydrogen-to-carbon ratio and the combustion chamber efficiency. Diagram III is an enthalpy-entropy chart for 1 Kmol. of air or gaseous fuel. It is similar to Diagram I except that its upper temperature limit is 1,000 deg. C. and, on the left of it, is traced a set of lines corresponding to values of r from 0 to 0·7, intersected by sets of isothermals which enable a wide range of composition of working mixture to be accommodated on a single chart. Printed on stout paper and of a size large enough to permit of interpolation, these useful diagrams will materially lessen the labour involved in gas-turbine calculations.

Proposed New Bridge Over the River Tagus.—Although the completion, last year, of the Vila Franca bridge over the River Tagus at Lisbon, Portugal, has already provided a short link between Lisbon and the south bank, a commission has been set up to examine proposals for a shorter connection over a second bridge carrying railway tracks as well as a road across the Tagus. The Vila Franca bridge was fully described in Engineering, vol. 172, page 801 (1951).

THE PERFORMANCE OF JAW CRUSHERS.

By K. Gauldie.

(*Concluded from page* 458.)

At every hopper level there is, of course, a definite speed at which material descending past that level can just regain contact with both jaws at the instant when the moving jaw has reached the limit of its backward stroke; that is, for every hopper level there is a corresponding local critical speed. For the particular case at nip level, that speed is

$$N_f = \frac{417}{\sqrt{h_f}}. \quad . \quad . \quad . \quad (18)$$

At higher speeds the feed material cannot fall the full distance h_f, but falls through some lesser distance, s_f, at every stroke; that is, the distance s_f, through which material descends per stroke past nip level is less than, or equal to, the height h_f, according as the speed of the machine exceeds or does not exceed its local critical speed, N_f, at nip level.

In terms of the angle α', through which the eccentric has moved past its backward dead centre at the instant when the moving jaw has just regained contact with the material falling past nip level, the distance, s_f, is (see equation 10),

$$s_f = h_f\left(\frac{1 + \cos \alpha'}{2}\right) = h_f Q, \quad . \quad (19)$$

and the area of the prism which descends per stroke past that level is

$$a_f = s_f b_f, \quad . \quad . \quad . \quad (20)$$

The corresponding speed is

$$N = \frac{1}{\sqrt{h_f}}\left[\frac{3{\cdot}27\,(180 + \alpha')}{\sqrt{1 + \cos \alpha'}}\right] = \frac{R}{\sqrt{h_f}}. \quad (21)$$

Sets of equations which apply to conditions at nip and outlet levels are now available; and the bond which links them together is the speed, N, which, of course, is the same at both levels.

A particular example will illustrate the application of these equations. In this particular case, the machine, with a hopper 24 in. wide, is designed with a narrow receiving opening and a relatively deep hopper for secondary crushing, on the lines of Fig. 4. The feed material is of 4-in. one-way size (i.e., the hopper breadth, b, at the level where nip occurs is 4 in.). When the conditions permit of choke-feeding, the mean density of that material as it arrives at nip level is 75 lb. per cubic foot; and the maximum mean density to which the emergent material may be compacted is 120 lb. per cubic foot. The close setting, B, of the jaws is 1 in.; the jaw movement, M, is $\frac{7}{8}$ in.; the angle, ϕ, included between the jaws at the hopper outlet is 2 deg.; the height, H (always to be reckoned at M cot ϕ) is 25 in.; the height, h_f, at the 4-in. nip level is $2\frac{1}{4}$ in.; and the speed, N, is 300 r.p.m. The critical speed of the machine and the local critical speed at the 4-in. nip level are $\frac{417}{\sqrt{25}}$ and $\frac{417}{\sqrt{2{\cdot}25}}$, that is, 83·5 and 278 r.p.m., respectively.

The operating speed, 300 r.p.m., exceeds the local critical speed at nip level. The distance s_f, through which material descends per stroke past that level is, therefore, less than the height, h_f, and is an unknown which must be determined as a step in the calculation of output rate.

In this particular case, the operating speed and the height of the emergent wedges are related together by the equations

$$s = H Q = 25 Q,$$

and

$$N = \frac{R}{\sqrt{H}} = \frac{R}{\sqrt{25}} = 300 \text{ r.p.m.}$$

whence, from the latter equation, R is 1,500.

The corresponding value of Q, obtained from the Q R curve (Fig. 6), is 0·22, whence

$$s = 25 \times 0{\cdot}22 = 5{\cdot}5 \text{ in.}$$

The area of the emergent wedge is, therefore (equation 14)

$$a_e = 5{\cdot}5\left(1 + \frac{\frac{7}{8} \times 5{\cdot}5}{2 \times 25}\right) = 6{\cdot}03 \text{ sq. in.}$$

The operating speed and the distance through which material falls per stroke past the 4-in. nip level are related together by the equations

$$s_f = h_f Q = 2{\cdot}25 Q,$$

and

$$N = \frac{R}{\sqrt{h_f}} = \frac{R}{\sqrt{2{\cdot}25}} = 300 \text{ r.p.m.}$$

whence R is 450 in this case and the corresponding value of Q, taken from the Q R curve, is 0·985. The distance s_f is, therefore,

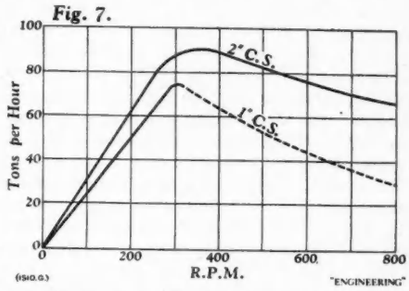
$$s_f = 2{\cdot}25 \times 0{\cdot}985 = 2{\cdot}22 \text{ in.}$$

The area of the rectangular prism which descends per stroke past the 4-in. nip level is, therefore,

$$a_f = b_f s_f = 4 \times 2{\cdot}22 = 8{\cdot}88 \text{ sq. in.}$$

and, presuming that the conditions permit of

Fig. 7.



choke feeding, i.e., that δ_f is 75 lb. per cubic foot, the density of the emergent material is (equation 15)

$$\Delta = \frac{8{\cdot}88 \times 75}{6{\cdot}03} = 110{\cdot}5 \text{ lb. per cubic foot.}$$

As that density is below the practical limit assumed (120 lb. per cubic foot), it follows that the presumption that the machine may be choke-fed, and that the mean density of the material arriving at nip level is 75 lb. as specified, is justified.

The output rate of the 24-in. wide machine, running at 300 r.p.m., is, therefore (equation 17):

$$T = \frac{300 \times 24 \times 110{\cdot}5 \times 6{\cdot}03}{64{,}500} = 74\tfrac{1}{2} \text{ tons per hour.}$$

At any speed less than the local critical speed at nip level, the distance s_f through which material falls per stroke past that level, is equal to the known height h_f, and need not, as in the preceding case, be calculated.

Proceeding in this manner for a series of values of the speed N, the following Table II is calculated. In those cases where the mean density Δ of the emergent material, calculated on the presumption that the machine may be choke-fed, exceeds the practical limit, that presumption is, of course, not justified; and the output rate is calculated on the basis that the feed rate to the hopper is so controlled that the emergent material is compacted to the practical limit. The Table is arranged in the natural sequence in which the calculations would be made.

The output speed curve for the 24-in. machine at 1 in. close setting, plotted from this Table, and the corresponding curve calculated for the same jaw plates at 2 in. close setting, are comprised in Fig. 7. In these curves, the ranges over which choke feeding would be practicable are indicated by the full line; and the ranges over which feed regulation by means external to the hopper would be necessary to maintain the mean density of the emergent material within the practical limit, are drawn in dotted line. At both settings the curves reach their maxima within the full-line ranges. It would be practicable, therefore, to operate the machine choke-fed at the maximum output rate at which the machine is capable, at either setting.

The various equations are, of course, valid only if the assumed conditions on which they are based are satisfied. Among the conditions which are assumed are: (1) Free descent begins immediately the moving jaw commences to move backward; that is, the material is assumed to be free-falling and non-sticky. (2) The angle included between the jaws at nip level is low enough to ensure that the largest lumps fed to the hopper are caught and broken without recoil. (3) The jaw surfaces at outlet diverge at constant angle for a distance above the outlet equal to the calculated height s of the emergent wedges. (4) The mean density of the material nowhere in the hopper exceeds the practical limit.

The attainable output rate of a crusher depends primarily on conditions at nip level and depends on the conditions at outlet only to the extent that the mean density of the emergent material must not exceed the practical limit. Attainable output rates depend, then, on the ratios $\frac{D}{B'}$ and $\frac{C}{D}$ (Figs 1, 3 and 4), because the angle included between the jaws at nip level depends on the former, and the jaw movement at that level depends on the latter. The higher these ratios, the greater is the area of descent at nip level and the greater is the mass of material which could be accepted at that level and would be discharged—provided that the fourth condition, above, is satisfied. The greater the mean density of the material arriving at nip level, the greater would be the mass of material that could be accepted at that level; that is, the mass of material that could be accepted would be greatest if the hopper were choke-fed. Choke-feeding, high $\frac{D}{B'}$ ratio and high $\frac{C}{D}$ ratio are, then, conditions consistent with the highest attainable output rate.

Everything that is accepted at nip level must, of course, be acceptable at all lower levels. The height and area of the emergent wedges in a crusher

TABLE II.

N	200	250	278	300	320	350	400	500	600	700
H	25	25	25	25	25	25	25	25	25	25
R	1,000	1,250	1,390	1,500	1,600	1,750	2,000	2,500	3,000	3,500
Q	0·41	0·29	0·25	0·22	0·195	0·17	0·135	0·09	0·065	0·046
s	10·25	7·25	6·25	5·5	4·88	4·25	3·38	2·25	1·63	1·15
a_e	12·1	8·17	6·95	6·03	5·30	4·57	3·57	2·34	1·68	1·17
h_f	2·25	2·25	2·25	2·25	2·25	2·25	2·25	2·25	2·25	2·25
R	—	—	417	450	480	525	600	750	900	1,050
Q	—	—	1·0	0·985	0·96	0·903	0·80	0·625	0·485	0·38
s_f	2·25	2·25	2·25	2·22	2·16	2·04	1·80	1·41	1·09	0·085
a_f	9·0	9·0	9·0	8·88	8·64	8·16	7·20	5·64	4·36	3·40
Δ	55·7	82·5	97	110·5	120	120	120	120	120	120
T	50	62·5	70	74·5	76	71·5	64	52·5	45	36·5

running at super-critical speed depend, however, on the speed at which the machine is operated. In a choke-fed crusher, the mean density of the emergent material would, therefore, increase if the speed were increased. In the particular case for which Table II was calculated, the length s, of the emergent wedges at a speed of 300 r.p.m. was 5·5 in., the mean density of the emergent material was 110·5 lb. per cubic foot, and the output rate at 1-in. close setting was 74½ tons per hour. If 110·5 lb. per cubic foot were the greatest mean density to which the emergent material could be compacted, no output rate higher than 74½ tons per hour would be attainable. At lower speed, the mass of material accepted at nip level would be reduced; and at higher speed the flow of material to the hopper would have to be restricted in order to maintain the mean density of the emergent material within the practical limit.

That output rate, however, would be attainable only if the hopper were of sufficient depth to satisfy all the necessary conditions; i.e., the ratios $\frac{D}{B'}$ $\frac{C}{D'}$ the operating speed, and the attainable output rate are inter-related. Had the operating speed been 250 instead of 300 r.p.m., the length s and the area a_s of the emergent wedges would have been 7·25 in. and 8·17 sq. in., respectively (see Table II); and had the jaw plates been so designed that the mean density of the emergent material was 110·5 lb. per cubic foot, the attainable output rate of the 24-in. machine would have been

$$250 \times 24 \times 8{\cdot}17 \times \frac{110{\cdot}5}{64{,}500} = 84 \text{ tons per hour.}$$

But, to attain that greater output, a much deeper hopper would be required.

Attainable output rates depend, then, on practical considerations; and, in general, the lower the $\frac{D}{B'}$ ratio the lower is the attainable output rate. For that reason, the output rates attainable in primary crushers (in which, for practical reasons, the $\frac{D}{B'}$ ratio is low, as in Fig. 1) are low in comparison with those attainable in machines designed as in Fig. 4, for secondary crushing.

Before any output rate, calculated from conditions at nip and outlet levels, can be accepted as attainable, it is necessary to confirm that at no intermediate level does the mean density of the material exceed the practical limit; that is, it is necessary to determine the level at which the area of descent is least and to base the calculations on that area.

The construction of the "area-of-descent" curves of machines operating at, or below, critical speed has already been described; and typical shapes are illustrated in Figs. 1 and 3. In a crusher operating at super-critical speed, the "area-of-descent" curve must, however, be drawn for the speed at which the machine runs.

For the calculation of area of descent at any level where the local critical speed is less than the operating speed, equations (10), (13) and (14) are applicable. In using these equations for that purpose the values of b, h, and m at that level must, of course, be substituted in place of B, H and M.

The "area of descent" curve in Fig. 4 is calculated in that manner for a particular set of conditions, in which the area of descent is least at the outlet, and the mean density of the crushed material is highest at that level. Had the hopper depth been appreciably less, the minimum area of descent would have occurred at some intermediate level. In such a case the attainable output rate would probably be increased by designing the crushing surfaces for a higher running speed.

The degree of uniformity or the quality of the product of a crusher is, of course, a major consideration. At all speeds up to the critical, the greatest one-way thickness (E, Fig. 5) of the emergent fragments is equal to the open setting of the jaws; and the larger emergent fragments have a one-way size varying between the close and the open setting of the jaws. The more greatly the operating speed exceeds the critical speed, the more nearly, however, does the thickness E approach the close setting of the jaws and the more uniform is the product; and, as the operating speed of crushers designed as in Fig. 4, for secondary crushing, is ordinarily much higher than their critical speeds, the degree of uniformity of the product is high.

One of the variables in jaw-plate design, on which both output rate and quality of product depend, is the angle ϕ, included between the crushing surfaces at the hopper outlet. The attainable output increases as that angle is reduced and is greatest when the angle is zero; that is, the attainable output is greatest if the crushing surfaces at close setting are parallel for a sufficient length above the outlet—provided, of course, that all the necessary conditions can be satisfied. Also, as the one-way size of the emergent material cannot exceed the close setting of the jaws, the degree of uniformity of the product is greatest. As a parallel zone at the outlet is consistent with both highest quantity and highest quality of product, it is a condition of special importance in secondary crushing. When the angle ϕ is zero, the height H (always to be reckoned as M cot ϕ) is infinite. For this particular case, the critical speed is zero, Q is zero, and R is infinite (see equations 9, 10 and 13). Ordinary methods of calculation fail, therefore, when the outlet angle is zero.

In a machine provided with a parallel zone of sufficient length, the outfall of free-falling material begins when the jaw commences to move backwards and continues until the jaw has completed its next crushing stroke; that is, the descent at outlet continues during the whole period of oscillation of the jaw. The length of the emergent prisms, therefore, is independent of the jaw stroke and is equal to $\frac{g}{2}\left(\frac{1}{n}\right)^2$; and if all the conditions for highest output are to be completely satisfied, the height of the parallel zone must not be less than that length.

In a machine with a parallel zone, running at 300 r.p.m., that length would be 7·7 in., as compared with a wedge length of 5·5 in. in the case of the Table II machine; and, provided that the emergent material could be compacted to the practical limit, the parallel zone machine would have much the higher output. But to attain it a much deeper hopper would be required.

The length of the emergent prisms and the corresponding length of the parallel zone decrease very rapidly as the speed is increased. The difficulty of satisfying the conditions for the highest attainable output in a hopper of reasonable depth therefore decreases rapidly with increase in speed. By operating at 425 instead of 300 r.p.m., the length of the emergent prisms would be reduced from 7·7 in. to 3·85 in., and the length of the parallel zone could be halved. The conditions for highest attainable output rate could be satisfied, therefore, with a hopper of much less depth. Should the limiting density to which the emergent material could be compacted be 110·5 lb. per cubic foot, the attainable output rate of a 24-in. machine running at that higher speed with a close setting of 1 in. would be $425 \times 24 \times 3{\cdot}85 \times 1 \times \frac{110{\cdot}5}{64{,}500}$ = 67 tons per hour.

The output rate attainable with a hopper of the same depth would be much greater, however, if a parallel zone were not provided; but the product would contain material of greater one-way size and would be less uniform. The highest quantity and quality cannot both be attained. The best compromise may involve some sacrifice of both.

[In Table I of this article, on page 457, *ante*, the value of R corresponding to the 180-deg. value of α should have been ∞.]

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(*Continued from page* 469.)

The third in the programme of six papers presented at the Autumn Meeting of the Institution of Naval Architects, held in Holland from September 14 to 19, was that of Ir. J. H. Krietemeijer on "Optical Marking-off System for Plates and Sections in Shipbuilding." It was read and discussed at the afternoon session on September 15, the chair being taken by the President of the Institution, Viscount Runciman. A summary of the paper is given below.

Optical Marking-Off of Plates and Sections.

The marking-off of plates by optical means was introduced during the war in the quantity production of aircraft. Since the war, it has been adopted also in shipbuilding, and has been found to have considerable advantages in saving space, man-power, time and cost. The author, having to re-organise the shipyard of the Koninklijke Maatschappij de Schelde, at Flushing, decided to adopt this method, which he named "Optaf," from the Dutch description, "OPTisch AFschrijven." The paper compared the results with those to be expected from the normal method of marking-off in a mould loft. The optical method, Mr. Krietemeijer explained, consisted in the vertical projection of the lines on a plate by means of an optical projector mounted in the roof of the platers' shed.

A drawing is made to a scale of one-fifth or one-tenth full size, according to requirements, and a negative lantern slide, 9 cm. by 12 cm., is made from the drawing, giving a final linear reduction (usually) of 1 : 100. This is projected on to the plate, laid horizontally beneath the projector, and the projected lines, etc., are then marked out on the plate by unskilled labourers, under the supervision of a skilled man. The projector is fitted with either an arc lamp or a high-pressure water-cooled mercury-vapour lamp. The lenses enlarge the image from 75 to 100 times, and can be adjusted by remote control from the floor of the shop. The negative-holder can be moved horizontally in two directions at right-angles, and can be revolved in its own plane, also from the shop floor, by means of push-buttons. The aberration, unavoidable in lens systems, is only slight, amounting to about 30 mm. in a length of 10 metres, and can be corrected by constructing the marking table with a slight camber. The projected lines have a breadth of 1·0 to 1·5 mm., but are reasonably sharp. The marking-off is done by hammer and centre-punch, the written instructions, etc., being traced with white paint. In the case of frames, a series is drawn on one sheet, and moulds are made from the projection. The drawing-office technique required by the optical method necessitates some special instruction and practice, as the draughtsmen, working to small scales, have to wear magnifying glasses; these are carried in a frame which holds them about 1½ in. in front of the eyes, so that the wearer can look beneath them, if he wishes, without lifting the frame out of his direct line of sight. Examples given in the paper of actual times taken to mark-off typical plates, as compared with the old mould-loft method, showed savings in time of 66 per cent. to more than 80 per cent. In the case of the de Schelde yard, the adoption of the optical method instead of the traditional practice enabled a reduction in area to be made, amounting to 47 per cent. of the area formerly required.

Discussion.

Dr. E. C. B. Corlett, who opened the discussion, asked what was the effect on the eyes of the draughtsmen of the extreme accuracy necessary in the drawing, and of having to use optical aids to improve visual acuity. His second question concerned the curved projection plane. There was a 3-in. curvature in the projection of a large plate; that was not much, but surely it was possible to overcome it by optical methods? One method of approach would be to use a curved projection plane in the projector. A high-grade flexible film was

reliable and did not shrink. If the projection plane in the projector were curved, instead of the receiving plane on the marking-off table, it would permit of the direct marking-off of slabs on a frame; and the statement, in the paper, that "a few shipyards still use a scrive-board near the bending slab, on which the body plan or part of it is transferred," indicated a considerable disadvantage, because it meant duplication of work. The author had described an elaborate optical apparatus and a very highly developed drawing-office system, and yet men were transferring the projections to the plates with centre-punches and other crude methods. In the aircraft industry, the projection method was used, but they projected directly on to sensitised plates. The saving in labour would probably more than compensate for the cost of putting an emulsion on the plate and altering the blackout arrangements in the shed to suit. It would be possible to mark off the plates in seconds, once the image was in focus. The author had listed in the paper the advantages of the system described, and they were substantial, but there was another which could not be overlooked. It was that, in a new yard, it was considerably cheaper to arrange for optical marking-off than to install the traditional system. Apart from the saving in space, the saving in capital cost was well worth taking into account.

Ir. G. De Rooij asked whether any special training was necessary for the optical draughtsmen. Were the draughtsmen interested in the new method, or were they more or less sceptical about it? They were working mainly with magnifying glasses and he wondered whether their eyes became tired. Again, were the advantages of the optical method the same for the small yard as for a larger one? If not, what was about the minimum capacity of a yard which would warrant the installation of the system? It seemed possible that the activities in the shops of a shipbuilding yard would set up vibrations in the projector installation. What was the effect of such vibrations on the acuity of vision and the sharpness of the image? He asked also whether it was possible to lay out a whole section, consisting of several plates, on the marking-off table and to mark them off together. Finally, for what plate thicknesses could the electronic flame-cutting machine be used?

Ir. D. E. D. Romijn observed that, though the lines on the scrive-boards had a thickness of only 0·10 mm. when drawn on a scale of 1 : 10, the projected lines of the image on the plate still had a thickness of 1·0 to 1·5 mm., although they were quite sharp. He thought that the machines and the cranes in the platers' shed would cause a steady, and perhaps irregular, vibration of the lines. The marking-off apparatus was rigidly mounted on the roof of the platers' shop, but, after all, the height of the projector above the marking-off table was 14 m.; there was a slight deviation caused by the prevailing strong westerly winds, which would move the shed some millimetres to and fro. He wondered, therefore, whether the lines would be projected and marked off accurately enough to satisfy the high demands of the Bureau of Ships of the Navy. He would be glad if the author would state what was his experience, and that of other yards, in regard to the accuracy of complicated and special forms.

Professor Ir. H. E. Jaeger said that he was convinced of the enormous advantages of the optical marking-off method. It had been discussed for many years, and he was glad to have been able to encourage the author to apply it in his yard at Flushing. The great disadvantage of welding in ship construction was inevitable shrinkage of the plates, but the optical marking-off system could be so applied as to take the shrinkage into account. That was one of the big advantages of the method. A method which had been adopted by one yard in Holland was to use a mathematical formula to put the lines on the board. Mr. Rosingk, who was responsible for that development, had told him of its application to a very big ship. If that method was used in connection with the optical system, it could be applied directly in the drawing office, with an accuracy which was very good.

Mr. M. F. Gunning said that, during the war, he had seen a great deal of shipbuilding in England, and he thought that the system described by Mr. Krietemeijer might have a good effect on shipbuilding in war time if it were properly organised beforehand. Large numbers of identical ships had been built during the war—submarines, frigates, landing craft, "Victory" ships, "Liberty" ships, etc.—the designs of which must have been prepared before the war. If, at that stage, not only the drawings had been available, but also the provision for marking-off the plates of the ships, there would have been a saving of time extending into weeks and months at a time when the ships were needed very urgently. Had Mr. Krietemeijer considered that aspect of the matter, and, if so, could he say something about it?

Ir. Krietemeijer, in reply, said that, with regard to Dr. Corlett's question about the effect of the use of magnifying glasses on the eyes of the draughtsmen, they had had no difficulties in that respect, nor, he believed, had other yards, in Sweden, Germany and Belgium. He had heard rumours that, in one yard in Belgium, where the system had been used for three years, the draughtsmen's eyes had become better instead of worse. His own men did not object to using magnifying glasses. Dr. Corlett said that the rounding of the marking-off table was 3 in., but that was not so; it was 3 cm., or about 1¼ in. They had considered the system that he proposed, of rounding the tables on which the drawings were laid and then photographing; that system had not been developed to a high degree, but he thought they might expect developments in that direction. They had also considered the system of providing the plates with a sensitive layer, using it as photographic paper, but it was too expensive. He knew that it had been used in the aeroplane industry, but its application was very difficult in shipbuilding, where the plates were rather rough in comparison with the aluminium plates used in aircraft. One Belgian yard investigated it, but found it to be too expensive and did not adopt it. He agreed with Dr. Corlett that, when establishing a new yard, the optical marking-off system was cheaper to install, and much more economical to use, than the normal method, because the investment in large buildings was much less and the investment in the apparatus was not so high; two sets of the equipment would cost about 70,000 Dutch guilders (about 7,500*l.*).

Mr. de Rooij had asked how they enabled people who have been employed on marking in the yard to become draughtsmen, and he had also been asked if the change was similar to that from riveting to welding. As a matter of fact, not many riveters in their own yard become welders; they remained riveters. He believed that most of the welders came from another direction. When men progressed from the yard to the drawing office, they liked the work very much and did it with a high degree of accuracy. It was their practice, when introducing new methods or systems, to inform the men beforehand; he had done that personally by lecturing to the workmen, so that they know what was going on. Of course, some of the markers employed in the shop feared that their services might be dispensed with, but they could be employed on the welding floor, for laying out and fitting together the several parts of the sections. It was not easy, but it could be done. The men who became draughtsmen were more keen to develop new methods than they were when working in the rough and dirty surroundings of the yard.

He believed that the optical system could be used in the small yards, with small projectors, as well as in the big yards with larger projectors. The problem of vibration was rather important, and it was difficult to solve. He supposed that the ideal solution would be to build a separate tower for the projector, but that was rather expensive, and, after much consideration, they decided to build the cabins on the roof. Experience at several yards had shown that small vibrations did not matter. One yard made an investigation, in the course of which artificial vibrations were produced; the projected lines, instead of being 1·5 mm. thick, were 3 mm. and sometimes 4 mm. thick, but the workmen could centre the line just as well and the accuracy was as high as when there was no vibration. Several yards, however, had built their projectors in separate structures. The cranes in the shed, travelling under the projector, caused vibrations, but measurements taken with the projector fitted against the frame of the roof showed that the vibrations transmitted were very slight.

It was not often possible to use a whole section, consisting of several plates, under the projector because most sections were too big; the area covered by one projector was 10 m. or 11 m. or maybe 12 m. by 3 m., or perhaps, 4 m. There was a system, which he thought rather expensive, of using four projectors together and four slides in each projector, to cover a larger area; sections of 15 m. by 7 m. or 8 m. could perhaps be used thereby, but the rounding of the table was difficult. The electronic flame-cutting machine was an interesting development, and he had seen it cutting plates from 8 to 15 mm. in thickness, but he believed there was no objection to cutting thicker plates. The machine had been developed at a works in Germany, and he understood that, in the near future, two other firms—one in the United kingdom and one in Germany—would market machines operating on the same principles, and perhaps better.

In reply to Mr. Romijn, he thought that they could satisfy the high demands of the Bureau of Ships of the Navy. At the same time, he asked whether those demands could not be reduced, because he did not think it necessary to call for such a high degree of accuracy in fabricating the hulls of ships. As to experience concerning the accuracy of complicated and special forms, as far as he knew, they had not encountered that problem, but in other yards some 96 or 97 per cent. of the plates were marked by optical methods and the other plates were moulded on board the ships. He thanked Professor Jaeger for his remarks on shrinkage. It was possible to allow for the shrinkage on the drawing by calculation; it was a matter of the experience of the draughtsman, who could lengthen the plates to take up shrinkage. The foreman in the yard could also use his experience in reading the drawings. The mathematical calculation of the lines was of great interest. He did refer in the paper to the question of co-operation between shipyards, but Mr. Gunning had referred to the matter in more specific terms, particularly in connection with co-operation in war time, when great numbers of ships had to be built. He understood that the Germans had started an optical marking-off system in 1942 or 1943 in connection with the building of destroyers; if such a system had been used in the United Kingdom and the United States, a considerable saving in time and money could have been effected. The co-operation must be very close, of course; all yards must use the same slides and the same apparatus.

(To be continued.)

THE USE OF ELECTRICAL RESISTANCE STRAIN GAUGES ON CONCRETE STRUCTURES.*

By J. C. Lucas, B.Sc. (Eng.), and R. Newsham, G.I.Mech.E.

During the past two years, considerable research has been carried out on concrete structures using electrical-resistance strain gauges. In the initial stages of the work, certain difficulties arose owing to deterioration of the gauges and adhesives due to the action of moisture and free alkali in the concrete. Originally, the authors used gauges which were manufactured in their laboratory and had a 6-in. gauge length comprising Constantan wire of 0.001-in. diameter cemented between two layers of thin paper by Durofix.† The gauge was then attached to the concrete with Durofix after the test surface had been filled with plaster of Paris. These gauges proved highly satisfactory when used under laboratory conditions, but when used out of doors very rapid deterioration of the gauge adhesive took place. When the gauges were waterproofed with Di-Jell

* Communication from the Engineering Division, Railway Executive Research Department, Derby.

† Durofix is a cellulose-acetate cement made by the Rawlplug Company, Limited, Rawlplug House, Cromwell-road, London, S.W.7.

"171"* and oil-silk, the deterioration of the gauge was even more rapid owing to the inability of the moisture present in the concrete to evaporate.

The first stage in the development of the technique described below was to investigate the use of Araldite "102" with Hardener "951,"† as the adhesive for fixing the same gauges to the concrete. A thin layer of Araldite "102" was spread on a specimen, and, after hardening for four days, was immersed in a very strong solution of sodium hydroxide to simulate alkali conditions considerably more severe than would obtain in practice. After immersion for two days, the layer of Araldite had not shown any visible signs of deterioration. As a result of this test, a number of paper gauges were attached by Araldite to a set of concrete prisms and exposed to the weather, but these gauges again showed rapid signs of deterioration, especially at the layer of Durofix joining the two paper sheets, although the Araldite appeared to be unaffected. Experimental gauges were therefore made, using Araldite "102" for the assembly of the gauges as well as for attaching them to the concrete, but difficulty was experienced in manufacturing a gauge to the required degree of accuracy due to the long setting time of the Araldite.

Printed foil gauges‡ with a 1-in. gauge length became available at about this time. In the mechanical testing of concrete, it is desirable to use a gauge length of at least 3 in. (an aggregate size of $\frac{3}{4}$ in. being commonly used for prestressed concrete), so three of these gauges were wired in series at each gauge position. For the first series of tests, foil gauges were attached by Araldite "102" to the sides of a number of 4-in. by 4-in. by 16-in. concrete test prisms, using plaster of Paris as a filling medium for the concrete. Plaster of Paris was later abandoned as a filler because it did not always bond itself satisfactorily to the concrete; furthermore, the Araldite itself was found to function satisfactorily as a filling agent. One of the prisms was then immersed in hot water and subjected to a number of cooling and heating cycles for four days (the gauges were not waterproofed) without any measurable change in its leakage resistance or of deterioration of the gauge or of the adhesive. Another prism was exposed to severe weather for one week in February, including being buried under snow. These gauges again showed no sign of deterioration or change of earth leakage resistance, the worst resistance measured being 1,000 megohms. Difficulty was then experienced when using Araldite "102" out of doors during inclement weather, the adhesive not drying very satisfactorily and leaving the gauges with a slight leakage to earth. Araldite "D" with Hardener "951" was then tried with somewhat better results but, likewise, was not considered to be completely satisfactory. A solution to these difficulties was found by allowing the Araldite partly to polymerise in a dry atmosphere before application to the concrete surface.

The method finally adopted for the attachment of foil strain gauges to concrete was as follows. The test surface was ground and sanded to remove the loose mortar top and to obtain a smooth surface, a wire brush being used to remove any sand particles. Traces of free alkali were neutralised by washing the test surface with a suitable agent (2 per cent. $ZnCl_2$, 3 per cent. H_3PO_4, in water, diluted four times just prior to use). Traces of the neutraliser were then removed by washing with water and the specimen dried with a hot-air blower and, where possible, left in a dry atmosphere for 24 hours. Traces of mould oil were then removed by swabbing the surface with trichlorethylene, which readily evaporated. Sufficient Araldite "D" was then mixed and heated at 50° deg. C. for 10 minutes and, while still hot, applied liberally to the specimen so as to fill all the voids, and the surface dressed-off smooth and left for 24 hours. The gauges were then washed in trichlorethylene and a thin layer of the adhesive applied to both the gauge and the concrete, which were then immediately clamped together. After a further lapse of 24 hours, the leads were soldered into position and a coating of Araldite applied over the gauge as well as the ends of the leads to form a waterproof protection.

It was also found necessary to attach gauges to 0·276-in. diameter prestressing wires and to cast them into the concrete. To do this, foil gauges were first moulded round a piece of wire 0·2 in. in diameter, and then heated to 60 deg. C. and allowed to cool while still formed to the wire. This shaped the gauges to 0·2-in. diameter so that, when attached to 0·276-in. diameter wire in the normal way, the curl was sufficient to hold the gauge in contact with the wire during the curing of the Araldite, the only external clamping being a piece of cotton or string tied round the connection end of the gauge. After attachment, the gauge was covered with a layer of Araldite, the connecting leads turned back over the gauge and embedded in this layer (this prevented the leads from being pulled from the gauge during casting of the concrete).

The gauge was then given a coating of Di-Jell and a final covering of oil-silk to give mechanical protection during casting, and to permit a small amount of slip between concrete and wire at the release of tension of the wire. P.V.C.-covered connecting leads were used from the gauge and these were wrapped round $\frac{1}{8}$-in. diameter iron wire and brought out from the top of the concrete.

The method proved to be satisfactory when concrete beams were manufactured under factory conditions. Printed foil gauges attached in this manner to 0·276-in. diameter wire, when tested in the laboratory, gave a scatter in gauge factor of less than $\frac{1}{2}$ per cent.

* Di-Jell "171" is a petroleum jelly-like material made by Astor Boiselier and Lawrence, Limited, Norfolk House, Norfolk-street, London, W.C.2.

† Araldite "102" and Araldite "D," used with Hardener "951," are cold-setting resin adhesives made by Aero Research, Limited, Duxford, Cambridgeshire.

‡ Foil gauges are made by Saunders Roe, Limited, East Cowes, Isle of Wight, under the trade name of Technograph. A description of the gauges has already been given in ENGINEERING, vol. 175, page 119 (1953).

THE IRON AND STEEL INSTITUTE.

A SPECIAL meeting of the Iron and Steel Institute was held in the Netherlands from September 30 to October 6. Most of the visitors arrived in Amsterdam, the main centre of the meeting, during September 30 and the meeting opened on Thursday morning, October 1, when visits were paid to Werkspoor N.V.-Amsterdam, the Amsterdamsche Droogdok Maatschappij, the Nederlandsche Doken Scheepsbouwmaatschappij and Asscher's diamond factory. The Werkspoor engine works at Amsterdam occupy a total area of nearly 34 acres, about 21½ acres of which are covered by buildings. Adjacent to the works are deep-water berths, and good railway connections are also available. High-speed marine and other types of Diesel engines, water-tube boilers, steam turbines, air compressors and fans are among the products of the firm. The company possess a works at Utrecht in which rolling stock, including locomotives, tramway cars and other types of vehicles, and also bridges and steel structures are built. The Amsterdamsche Droogdok-Mij, or Amsterdam Drydock Company, own four floating docks, of 3,000, 4,000, 7,500 and 25,000 tons lifting capacity, respectively. In addition to repairing ships, which is the main activity of the company, there is a large department for building new ships, engines and boilers. The yards of the Netherlands Dock and Shipbuilding Company are situated on the north bank of the Ij, which gives access to the harbour and to all the canals of Amsterdam, and is connected to the sea by the North Sea Canal, reaching the coast near Ijmuiden. In 1952 the shipyard launched seven vessels having an aggregate gross tonnage of 90,945 and, in the same year, repairs were carried out to 272 ships, while a total gross tonnage of 1,271,725 of shipping was dry-docked. Asscher's diamond factory was built in 1906, although the firm was established about 40 years earlier. The work carried on includes the cleaving, sawing and polishing of diamonds.

Technical Session.

On Thursday afternoon, an official welcome and technical session were held in the large conference hall of the Grand Hotel Krasnapolsky, Amsterdam. Mr. A. H. Ingen Housz, the President of the board of the Royal Netherlands Blast Furnaces and Steelworks, Limited, and chairman of the reception committee, took the chair and welcomed the visitors on behalf of the Federation of the Netherlands Steel Industry and also on behalf of his own company. He stated that officers and members of a small and young industry were welcoming their friends in an industry which was old in years and experience. In the course of his reply, Mr. James Mitchell, C.B.E., President of the Iron and Steel Institute, said that Mr. Ingen Housz had been too modest in his reference to the Dutch steel trade; an industry was measured by its efficiency rather than by the scale of its operations.

Mr. Ingen Housz then delivered a lantern lecture on "The Iron and Steel Industry in the Netherlands." He stated that for many centuries the people of Holland had been farmers, sailors and merchants, and the steel industry had been developed rather late in the history of the country. The oldest steelworks in the Netherlands was the plant now known as the Demka Works of the Royal Netherlands Steelworks, Limited. It had been developed from an iron foundry established 50 years ago on the site of an older works which had been in existence for over 100 years. In 1913, the firm had been transferred from its original site in North Holland to the present works at Utrecht. In 1919 rolling-mill and other shops had been added as the demand for a diversity of products had arisen. Another company, the Netherlands Cable Works, Limited, had felt it desirable to establish, in 1937, a steelmaking plant with rolling and finishing facilities to produce the hot and cold-rolled strip and the galvanised round and flat steel wire required for armouring its cables. The plant, which consisted of an open-hearth steel melting shop and rolling mills, possessed excellent water-transport facilities for its raw materials and finished goods.

When, in 1917, it had been decided to establish the Royal Netherlands Blast Furnaces and Steelworks, Limited, the consumption of steel in the Netherlands was about one million tons per annum; at present it was 1½ million tons. In 1920, a commencement had been made on the erection of the works, and, in January, 1924, one blast furnace and one coke-oven battery were put into commission. A year later a second blast furnace and coke-oven battery had been started up and, at present, the works had in operation three blast furnaces, four coke-oven batteries, an artificial-fertiliser factory, a blast-furnace slag cement-making plant, a cast-iron pipe factory, an open-hearth steel-melting shop, a heavy-plate rolling mill, a blooming and slabbing mill, a wide-strip mill and a tin-plate plant. The works employed a total of about 8,500 men and great attention was paid to the question of human relations.

A second lecture, on "The Investigation of Luminous Flame Radiation at the Ijmuiden International Research Centre," was delivered by Mr. G. W. van Stein Callenfels. This we hope to reprint in our columns in a future issue. The second lecture should have been given by Professor J. E. de Graaf, on "Research and Development in the Iron and Steel Industry in the Netherlands," but owing to the illness of the author it was arranged that the lecture on flame radiation research should be given in its place. The technical session was brought to an end by the showing of a sound film "The Great Jib," a description of the design and construction of the tubular steel jib of the W.1400 walking dragline excavator of Stewarts and Lloyds, Limited, Corby, Northamptonshire. At the close of the session Mr. James Mitchell, the President, announced that Mr. Ingen Housz had been elected an honorary vice-president of the Institute.

Other Visits to Works.

The whole of Friday, October 2, was devoted to a visit to the Ijmuiden Works of the Royal Netherlands Blast Furnaces and Steelworks. The three blast furnaces each produce 600 tons of pig iron a day and the four batteries of coke ovens, comprising, in all, 118 ovens, have a daily consumption of 1,600 tons of coal slack, obtained partly from home sources and partly from Germany and the United States. There are five 180-ton open-hearth furnaces in the steel melting shop and the blooming and slabbing mill has a capacity of 600,000 tons of ingot

TESTING DOMESTIC ELECTRICAL APPLIANCES.

FIG. 1. LABORATORY FOR PORTABLE APPARATUS.

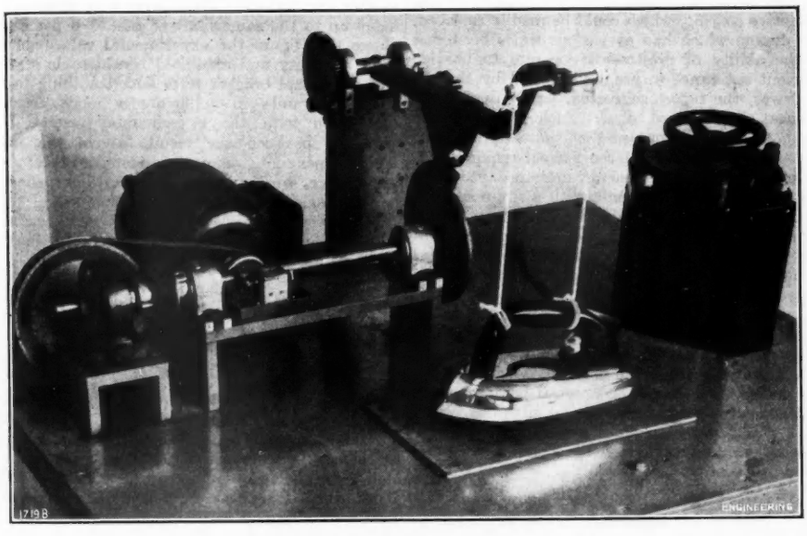


FIG. 2. REPEATED DROP TEST FOR SMOOTHING IRONS.

a year. The heavy plate mill has an annual output of 250,000 tons of plate ranging from ¼ in. to 1¼ in. in thickness.

On Saturday, October 3, a visit was paid to the Demka Works, near Utrecht, of the Royal Netherlands Steelworks, Limited. The present works occupy an area of 75 acres and adjoin one of the main waterways linking the Rhine to Amsterdam. Ships of up to 3,000 tons can be berthed at the works quays. The whole of Monday, October 5, was spent in Delft and the Hague, and visits were paid to the National Testing Institute and the general-metallurgy, physical-chemistry and applied physics laboratories of the Technical University of Delft. The last day of the meeting, Tuesday, October 6, was spent in Rotterdam, when the Rotterdamsche Droogdok Maatschappij (Rotterdam Drydock Company) and the N.V. Nederlandsche Kabelfabriek were visited. The Rotterdam Dry Dock Company own several floating docks, the largest being of 32,000 tons. By 1952, 25,000 ships had been handled for maintenance and repair since the foundation of the company in 1902. In addition, some 290 ships have been built in the shipyard to date. The company's works now cover over 258 acres and employ upwards of 5,000 men. The steelworks of the Netherlands Cable Works, Limited, at Alblasserdam, contain three 35-ton basic open-hearth furnaces and two 25-30-ton electric-arc furnaces. The rolling-mill plant comprises a continuous billet mill, a continuous strip mill and a continuous rod mill. The total floor area of the works buildings is 600,000 sq. ft. and the number of employees about 1,300.

The meeting closed on the evening of October 6 with a dinner at the Atlanta Hotel, Rotterdam, by invitation of the firms in Rotterdam.

NEW FACTORY FOR DOWTY EQUIPMENT OF CANADA LIMITED.—On Tuesday, October 13, Air Vice-Marshal D. M. Smith, C.B.E., C.D., the Air Member for Technical Services, opened a new factory, known as the North Plant, for Dowty Equipment of Canada Limited, at Ajax, Ontario. The Dowty group have been operating in Canada since the beginning of the second World War, and they constructed most of the landing gear and hydraulic equipment used in Canadian-built aircraft during the period of the war. They also manufacture wheels and brakes for the Dunlop organisation, and operate a repair base for aircraft equipment.

TESTING DOMESTIC ELECTRICAL APPLIANCES.

IMMEDIATELY after the war, the production of domestic electrical appliances increased greatly, but much of it was of poor construction. Consequently the British Electrical Development Association, 2, Savoy-hill, London, W.C.2, established a testing house in 1947 to test appliances for their efficiency and safety in use. The scope of the work increased and now a new testing house has been built at Leatherhead. The official opening was performed by the President of the Association, Sir Henry Self, on October 5. The laboratories were open for inspection and exhibitions of the work were arranged. The rooms are well equipped with electrical supplies and services, both alternating current and direct current being available, the latter from storage batteries. There are also compressed air and water supplies. The two main laboratories are for portable apparatus which, being mainly small, requires bench room, as shown in Fig. 1, and for larger apparatus such as washing machines and cookers. There are a controlled temperature and humidity room which is used for testing apparatus under special conditions, and a screened room for measuring radio interference. In addition, a life-test room, a photographic room, workshop, stores, etc., are provided.

Performance tests are now being carried out, in addition to ordinary safety tests. Washing machines, water heaters, and cookers all have to conform to the requirements of the respective British Standard. So do fires, blankets, heating pads, irons, vacuum cleaners and many other appliances. Fig. 2, herewith, shows a drop test for a smoothing iron; it is intended to simulate hard usage in the home. The iron is dropped from a height of 1½ in. on to a steel plate at least 1,000 times—more violent treatment, one hopes, than it would receive in the normal course of ironing. Electric blankets are run around two rollers for long periods, heating pads are shaken in a tumbler and washing machines run under full-load conditions for many hours. Part of the testing of a cooker is to ensure that the oven is evenly heated. To do this, scones of fixed composition and size are baked and the degree of browning checked against a standard chart. The height of rise is also measured. For this purpose the dough is rolled to a definite thickness with a special rolling pin. Hot plates have a 3½-lb. steel ball dropped on them from a height of 6 in., normally without any damage being done.

Where the appliance is intended for export, it is tested according to the specification of the country concerned, and so the manufacturer can know beforehand whether the product will be acceptable. At first, nearly all the articles submitted came from individuals, but now 58 per cent. come direct from the manufacturer. It is of interest to note that, of all those received last year, 90 per cent. were rejected for some defect. Any person or firm can submit articles for test, but although an accurate report is prepared, the findings of the testing house have no legal status.

ASSEMBLY OF DAVID BROWN TRACTORS IN INDIA.—A consignment of light wheeled tractors, dispatched from the works of David Brown Tractors (Engineering), Ltd., at Meltham, Yorkshire, reached Bombay recently. The tractors were shipped completely dismantled and without tyres or tubes, and their arrival was the first step in a progressive plan for the assembly of the firm's vehicles in India. This work will be carried out by Mahindra and Mahindra, Ltd., recently appointed sole concessionaries in India for David Brown tractors, at their assembly plant in Bombay, and under the supervision of their own technicians, some of whom have lately attended instructional courses at the David Brown works in Yorkshire. Future consignments to India will include larger wheeled vehicles. At a later stage, it is expected that arrangements will be made for the assembly of the complete David Brown range of machines, comprising four wheeled vehicles and two crawler tractors, in Calcutta as well as in Bombay. Subject to the approval of the Government of India, Messrs. Mahindra hope to manufacture, or supply from Indian sources, an increasing number of components for the vehicles.

INTERNATIONAL FEDERATION OF PRESTRESSING.

As reported on page 500 of this issue, the International Federation of Prestressing held their first international congress at the Institution of Civil Engineers, from Tuesday, October 6, to Friday, October 9. The technical business of the congress was divided between three sessions, at which *rapporteurs* submitted a survey of the several papers contributed on the particular aspect to be discussed. The three aspects considered, and the *rapporteur* at each session, were: "The Influence of Abnormal Temperatures," by Mr. A. W. Hill; "The Ultimate-Load Design of Statically Determinate Beams and Slabs," by Professor G. Magnel; and "Statically Indeterminate Structures in the Elastic and Plastic States," by Mr. Y. Guyon. The information in this article has been drawn only from these three reports. In due course, the Federation hope to publish the full reports, together with written comments and the recorded discussion.

Effect of Abnormal Temperatures on Prestressed Concrete.

In the first of the technical sessions the conference discussed the problems of fire and extreme cold on prestressed concrete. It is convenient here to commence with the effects of low temperature; the information submitted to the conference was drawn solely from one piece of research carried out by Mr. G. Huygle at the University of Ghent. The tests made use of two reinforced-concrete T-beams, two prestressed I-beams and appropriate 8-in. and 4-in. control cubes. The beams were tested in bending on a span of 19 ft. 8 in. at an age of 30 days, one of each type at + 20 deg. C. and one at − 40 deg. C., each with sets of control cubes. Although of limited scope, the tests on the cubes gave a clear indication of increased strength and modulus of elasticity at the lower temperature as compared with normal temperatures, and the tests on the beams confirmed these observations, the cracking and ultimate loads being higher, and the deflections lower, at − 40 deg. C. than at + 20 deg.C. It was observed that the reduction in deflection might indicate a reduction in impact resistance; this point was not fully established, however, the increase in modulus possibly being fully compensated by the increase in compressive strength.

That part of the report dealing with fire resistance comprised a review of the work so far carried out under British Standard test conditions at the Fire Research Station, Elstree. The *rapporteur* began with a broad definition of fire resistance and pointed out that, strictly speaking, the definition could not be applied to materials of construction but only to elements of construction, in particular, prestressed concrete floors and ceilings or prestressed beams and columns. The three principal requirements of a structural element were that, during a fire, it should not collapse suddenly; secondly, that the fire should not be able to spread to adjacent areas by permitting the flames to penetrate holes or cracks and that the element should provide sufficient insulation to limit the transmission of heat; thirdly, the element should be amenable to restoration after the fire. Structural elements were tested under conditions which simulated their normal working condition of loading and support (the loading being increased by 50 per cent.) and the period during which the element remained rigid and had not collapsed was its fire-resistance. In the case of a wall or floor, it was further required that the temperature on the unexposed face should not average more than 250 deg. F., nor anywhere be more than 300 deg. F. above the temperature reached on the exposed face. In conjunction with these properties, by-laws required that any given building should have a particular minimum fire resistance and the report gave details as specified in the model by-laws of the Ministry of Housing and Local Government for various classes of building.

The fire resistance of prestressed concrete depended primarily on the thickness and low thermal conductivity of the cover concrete above the reinforcing cables. The rate of decrease in strength of high-tensile steel wire was much greater than that of mild steel, from which it could be inferred that the amount of cover provided was of greater importance for prestressed concrete. While for mild steel various authorities gave the critical temperature (at which the ultimate strength had been halved) as between 400 deg. and 550 deg. C., the limiting temperature for high-tensile steel appeared, from work so far completed, not to be above 400 deg. C. The apparent disadvantage suffered by prestressed concrete, as compared with reinforced concrete, was offset by the greater depth at which the steel was usually buried; in reinforced concrete the steel was necessarily as close to the tension surface as other factors permitted, but for prestressed concrete the tendons were more usually distributed uniformly across the section.

Particular experiments on points of detail had shown that the ultimate compressive and tensile strengths of high-quality concrete appeared to decrease considerably when the concrete was exposed to high temperature; that the behaviour of sample specimens was not dependable for predicting the performance of a structural member; that complete failure of prestressed concrete was not to be expected in a fire, but excessive deflections were more likely to occur than in reinforced concrete, although the residual ultimate strength might be a high proportion of the original value.

The question of the cost of repairs to a structure after a fire had to be considered in relation to the extra initial cost of any protective methods adopted. But the great increase in fire resistance provided by lightweight encasements suggested that the cost of adequate protection was not excessive and any damage incurred might then be limited to the protective coating, which could be readily replaced. The doubts which had at various times been cast on the ability of prestressed concrete to provide sufficient resistance to fire, as required by the by-laws, was, the report suggested, partly due to the absence of published data. Such work as had now been done had proved that the material could be designed to withstand the normal requirements for fire resistance. In general, present-day designs produced structural elements with a fire-resistance period of two hours, suitable for almost all classes of building except large public buildings, particularly of the type used wholly or predominantly for storage. The modifications required to extend the range of fire resistance to include these buildings, by achieving a four-hour resistance, involved either a further increase of 2½ in. in the concrete cover provided or the additional provision of a ½ in. lagging of vermiculite plaster. The latter was thought to be the most economical because of its smaller deadweight, which gave an advantage both initially and in the event of a fire, when the permanent deflection would be lessened and repair work would be easier.

Ultimate-Load Design of Prestressed Concrete.

Five papers were submitted on the ultimate-load design of prestressed concrete—four of them proposing an ultimate-load formula for prestressed concrete beams. Before considering the formulæ the delegates were advised to appreciate that the ultimate load might be one of several values: it might be the limiting load applied in a fairly rapid static test; or the smallest load bringing about failure if applied permanently; or it might be the fatigue load bringing about failure after a large number of applications. Although the second and third of these conditions were of greater importance in practice, the formulæ were necessarily based on experimental results obtained from static tests. Of the types of failure possible, five separate cases could be recognised: where the steel failed prior to the concrete reaching the plastic state; by the concrete being crushed, the steel first reaching the plastic state; the concrete crushing, the steel not becoming plastic; shear failure; and bond failure. The opinion was expressed that beams likely to fail from either of the last two causes, and perhaps the third cause also, were to be eschewed, as these failed without warning.

Each contributor recognised that the effectiveness of the bond engendered between the tendons and the concrete was significant but conflicting experiences were reported. In particular, the relative effectiveness of the bond in the case of pre-tensioned and post-tensioned cables was a subject for difference of opinion, one contributor noting that the bond in post-tensioned beams was markedly inferior to that where the wires were first tensioned and the concrete then placed around them. Where the bond was poor, it was suggested that only one crack developed prior to failure which occurred at a load not much greater than that causing the first crack and the attention of delegates was drawn to the severe curvature incurred over a short length of the beam under such conditions. It was suggested that great advantage accrued from providing between 1 and 1½ per cent. of untensioned steel in the tensile zone of the beam.

Of the formulæ suggested, all of them could be reduced, by the insertion of appropriate values for limiting stresses, to resemble closely the form

$$M = 14{,}800\ b\ d^2\ p \text{ (in kg.-cm. units)},$$

where M is the ultimate bending moment, b the breadth, d the effective depth and p the proportion of steel, i.e., $\frac{A}{b\,d}$ where A is the steel area. The value of the numerical coefficient varied slightly between the several formulæ, but the difference was relatively small. The formula proposed by two of the contributors contained an additional coefficient, $\left(1 - \frac{p\,t}{2\,C}\right)$, where t and C were the ultimate strength of the steel and concrete respectively. For all practical values of p up to, say, 0·6 per cent., this factor was, to all intents and purposes, unity. For the experimental work quoted, the formula given above gave good agreement up to the same limit of $p = 0{\cdot}6$ per cent.; above that figure the experimental values showed some disparity and exhibited considerable scatter. The additional bracket term added nothing to the simpler formula in achieving a more accurate correlation with the experimental results. The variation between the results above the range $p = 0{\cdot}6$ per cent. was not considered to be of great importance, beams of such proportions generally being outside most practical requirements.

Note was made of an artifice now regularly adopted in Holland where two safety factors, s and s', were considered: firstly

$$s = \frac{M_{ult.} - M_d}{M_l} > 2{\cdot}5,$$

and secondly,

$$s' = \frac{M_{ult.}}{M_d + M_l} > 2{\cdot}0,$$

where $M_{ult.}$, M_d and M_l were the ultimate, dead-load and live-load bending moments. In this way, it had been possible to achieve a differential between the safety factor applied to loads known with a high degree of accuracy and those applied to loads about which there was an element of uncertainty. Two tests designed to determine the reduction in load capacity of beams when subjected to a repeated fatigue load had given results in close agreement, the average being a reduction to 62·5 per cent. of the static load. From this it could be deduced that, where elements were designed on allowed stresses deduced from static tests on sample specimens, the true factor of safety against failure by fatigue would also be 62·5 per cent. of that used in the design.

(To be continued.)

The Late Mr. F. S. Smith.—We regret to record the death of Mr. F. S. Smith, which occurred on Monday, September 14, at the age of fifty-four. Frederick Stretton Smith received his technical training at the Imperial College, London, and joined Callender's Cable & Construction Co., Ltd., in 1924. He was subsequently engaged with that firm on the development and improvement of methods of testing cables and locating faults.

The Late Mr. R. B. Waddington.—We note with regret the death of Mr. Reginald Boulton Waddington, of Ferriby, Yorkshire, which occurred on October 6. Mr. Waddington, who was district docks mechanical engineer at Hull, began his apprenticeship in the locomotive works of the Great Northern Railway Company at Doncaster in 1913. Subsequently, he became assistant works manager at Darlington and was transferred to Hull in 1945.

MARINE GAS TURBINE.

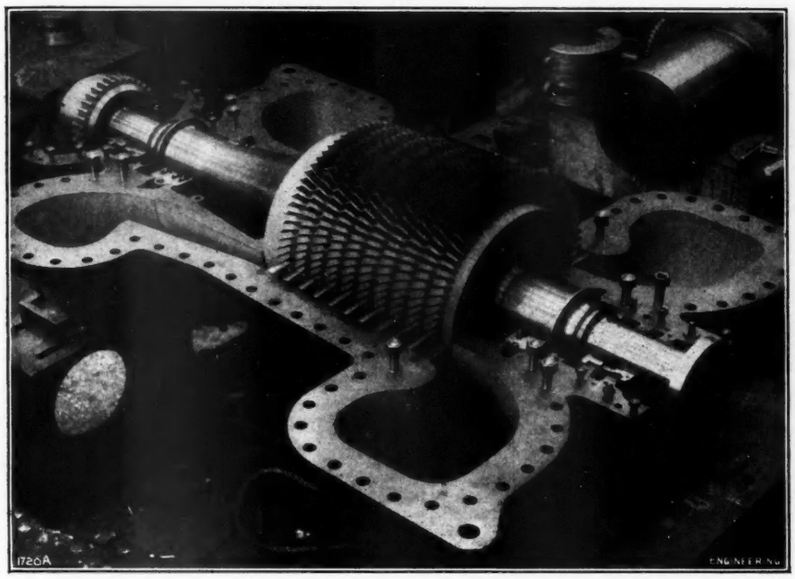
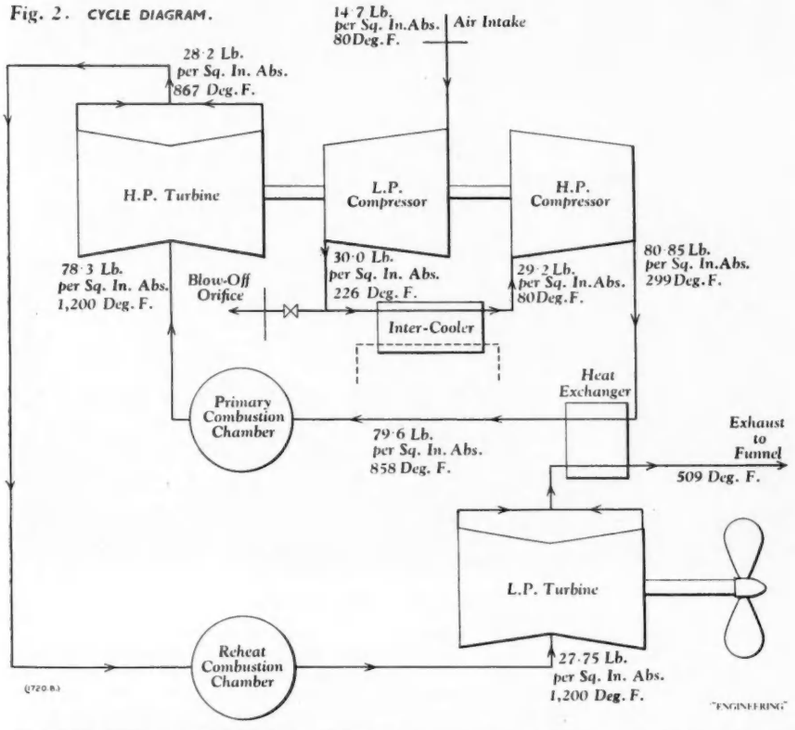


Fig. 1. Low-Pressure Compressor.

Fig. 2. CYCLE DIAGRAM.


14·7 Lb. per Sq. In. Abs. 80 Deg. F.
Air Intake
28·2 Lb. per Sq. In. Abs. 867 Deg. F.
H.P. Turbine
L.P. Compressor
H.P. Compressor
78·3 Lb. per Sq. In. Abs. 1,200 Deg. F.
Blow-Off Orifice
30·0 Lb. per Sq. In. Abs. 226 Deg. F.
29·2 Lb. per Sq. In. Abs. 80 Deg. F.
80·85 Lb. per Sq. In. Abs. 299 Deg. F.
Inter-Cooler
Heat Exchanger
Primary Combustion Chamber
79·6 Lb. per Sq. In. Abs. 858 Deg. F.
Exhaust to Funnel
509 Deg. F.
L.P. Turbine
Reheat Combustion Chamber
27·75 Lb. per Sq. In. Abs. 1,200 Deg. F.
(1720 B)
"ENGINEERING"

STABILISERS FITTED TO THE R.M.S. "ANDES."

The latest vessel to be fitted with the Denny-Brown stabiliser is the 25,676-ton liner Andes, the flagship of the Royal Mail Lines. The stabiliser was made by Brown Brothers and Company, Limited, Rosebank Ironworks, Edinburgh, in collaboration with William Denny and Brothers, Limited, Leven Shipyard, Dumbarton, and installed by Harland and Wolff, Limited, Southampton, over a period of 12 months, the work being continued each time the liner docked in this country; thus no operating time was lost. One of the reasons for installing a stabiliser on the Andes was the desire to provide a smoother crossing in the Bay of Biscay. During the earlier part of a voyage which commenced on September 29, from Southampton to Cherbourg Commodore H. D. Hooper made the ship roll and corrected the rolling with the stabiliser. The design of the stabiliser is based on a displacement of 18,000 to 27,000 tons and an average speed of 21 knots. Each fin extends 12 ft. from the hull and has a chord of 6 ft. 6 in., giving it an area of 78 sq. ft. At 21½ knots the righting moment on the ship was expected to be 5,500 ft.-tons, the effort from each fin being 70 tons. It is anticipated that a correction of 22 deg. will be achieved; thus a roll of 25 deg. will be reduced to 3 deg., i.e., 1½ deg. either side. The power for oscillating the fin shafts is provided by two motors of 50 h.p. each, and a 15-h.p. pump provides the power for extending and retracting. Full details of the design of the stabilisers were given in Engineering, vol. 170, pages 489, 526 and 557 (1950).

THE PAMETRADA MARINE GAS TURBINE.

The plant and equipment of the Parsons and Marine Engineering Turbine Research and Development Association (Pametreda) Research Station, Wallsend-on-Tyne, were opened on Monday, October 5, for inspection by members of the Press, and during the remaining days of the week they were seen by representatives of engineering and shipbuilding companies. Briefly, Pametrada was set up in 1944 by the shipbuilding industry with Government support. It has two main objectives—research and development—to ensure that the design of turbines for the marine engineering industry is kept in the forefront of world competition, and the full-scale testing of turbine installations. The activities of Pametrada were described by Dr. T. W. F. Brown, Research Director of the establishment, in a paper* entitled "A Marine Turbine Research and Testing Station." Since 1946 the station has received an annual grant from the Department of Scientific and Industrial Research.

One of the most interesting projects on view was the 3,500-h.p. gas turbine, which has been under development for some time. During a speech given by Sir Philip Johnson at the close of the tour, he said that while it would be comparatively easy to develop a turbine of this nature for burning expensive fuels, their object in designing such a machine was to produce a gas turbine which would give completely reliable performance at full power for duties at sea, have a life of 100,000 hours, and at the same time have a sufficiently high initial temperature to give an overall efficiency that would be competitive. The turbine on display had run successfully for a considerable time on Diesel oil, but before the right degree of economy could be attained it was necessary to obtain a satisfactory running performance on heavy oil. Recent work had given him cause to think that this was now possible. He ended his remarks by saying that the industry was prepared, with the aid of Pametrada, to design and install a gas turbine in any vessel, should they receive such an order.

The 3,500-h.p. marine gas turbine at Pametrada is shown in Fig. 10, page 496, viewed from the driving end, together with the reversing gear, and Fig. 2 herewith is a diagrammatic arrangement drawing. It is among the first gas turbines to be designed for marine duties and to drive the propeller directly. Last year a continuous run of 100 hours was completed at full power, after which it was opened up and inspected by Lloyds. The test was made using distillate fuel, and a fuel consumption of 0·505 lb. per brake horse-power per hour was recorded. In the early stages of development considerable change had to be made to both the low-pressure compressor, which is shown with its top casing removed in Fig. 1, herewith, and the high-pressure compressor. In the case of the low-pressure axial compressor the first runs showed a wide discrepancy between the design figures and the actual performance due to air swirling around the entry chamber; this was overcome by fitting splitters across the chamber to prevent the swirl. The next modification was to the inlet guide vanes, which are shown in Fig. 11, page 496, and a reduction was also made in the flow area through the compressor. Fig. 12, page 496, shows the outlet from the low-pressure compressor stage; it can be seen that the outer walls have been built up. Finally another stage was added, giving 11 stages in all. The performance figures now obtained from this compressor are almost identical with the design figures. In the case of the high-pressure compressor three modifications had to be made, including a correction to the incidence of the entry vanes to obtain stable flow. As can be seen in Fig. 2, an intercooler is fitted between the two compressors. Fig. 7, page 493, shows the eliminator elements employed to extract particles of water from the air stream.

Other difficulties, which were increased by the high operating temperature of a gas turbine, have also been overcome. Among these was the problem of distortion of the gas-turbine casing. The distortion

* *Trans. N.E.C. Inst.*, vol. 64, page 21 (1947-48).

PAMETRADA MARINE GAS TURBINE.

Fig. 3. Deposit on Turbine Blades.

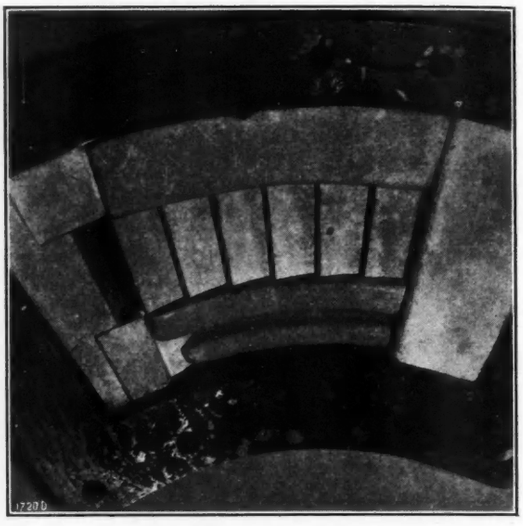


Fig. 4. Ceramic Cascade Blading.

was found to be due in part to the thermal inertia of the heavy flanges of the casing being greater than that of the actual casing. Thus the rate at which heat was transmitted through the casing varied considerably and produced ovality in the casing and also axial constraint. As a result of this the supports, which are placed at the ends of the casing, were tipped inwards due to the distortion of the end plates as the casing warmed up; this, in turn, caused the casing to drop in relation to the rotor. At first the cause was thought to be the difference in the heating-up rate of the heavy flanges and the lighter top and bottom casings. Measurement showed, however, that the whole casing was being restrained in the horizontal plane by the flange, and this was confirmed, when the turbine was opened for inspection, by the flanges springing apart at the ends to give a gap of 0·06 in. To reduce the constraining effect of the flange the casing is to be supported along the side instead of at the ends and saw cuts have been made from the edge of the flanges through to bolt holes.

In the field of combustion both static and dynamic rigs are being employed to study the problem of blade corrosion and to prevent the formation of deposits on the blades. Fig. 3, above, shows the blades of the turbine after an 84-hour run on heavy oil, at which time the test was abandoned due to compressor stall caused by the formation of deposits, which blocked the blade channels at entry to the turbine, as shown. Although corrosion, which is largely due to small quantities of molten vanadium pentoxide (a product of combustion in the ash) has been reduced by the use of an inhibitor, the quantity of the inhibitor and the transformed ash have increased sooting and blocking of the blade channels. These problems are primarily due to the use of heavy oil in which vanadium is almost always to be found, but, as has already been stated, the turbine must run satisfactorily on residual oils if it is to compete with marine Diesel engines. Already a wide range of inhibitors have been employed and some success has been achieved with additives of the basic metal-oxide type. These additives reduced the corrosion but failed to solve the problem of fouling. It is believed that some success has been achieved by the use of ethyl-silicate. Recently, a test run of about 40 hours was carried out satisfactorily and further tests are planned for the future.

While this work has been continuing on an uncooled gas turbine operating at 1,250 deg. F., research has also been going on to obtain sufficient knowledge to build a machine that will be capable of operating at temperatures up to 2,200 deg. F. To achieve this the turbine will have to use refractory material and special methods of blade cooling and protection. Fig. 4, above, shows guide vanes of a type suitable for use in the stator, arranged for test on a static rig. Vanes of this type are at present being tested at 2,200 deg. F. Rigs are also being employed to study blade cooling by water in a strong centrifugal field. Fig. 8, opposite, shows another of the blades which has been built for test purposes. The solid centre section has grooves cut on its surface and a metal facing is mounted over it to produce a normal blade. The covering material is porous after the manner of sintered metals; thus water or air can be fed up the grooves and out through the pores of the metal for the purpose of cooling.

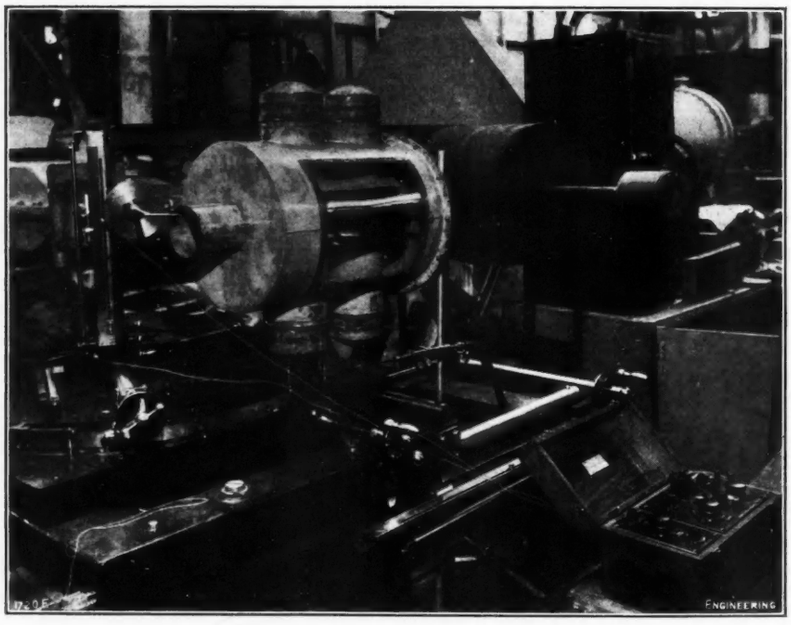


Fig. 5. Low-Pressure Air Test Rig.

A model of a new combustion chamber which is undergoing test and development for use in the high-temperature liquid-cooled gas turbine that it is proposed to construct is shown in Fig. 5. It consists of four flame tubes exhausting into a common mixing chamber. The advantage of this arrangement is that the gas reaches the turbine at a fairly uniform temperature under all conditions. In this way it is expected that the fuel supply of one or more of the flame tubes can be shut off at part load and a faulty burner can be changed in the same way. Different flame-tube positions are being tried to discover the arrangement that gives the best temperature distribution at outlet, together with the minimum pressure loss; at present, combustion tests are being carried out. The illustration shows an acetylene torch fitting into one of the flame tubes, an arrangement that has been employed in some of the test work.

Another particularly interesting feature of the gas turbine is the hydraulic coupling of the fluid-flywheel type which is being used. The coupling consists of two such units, one for astern running and the other for ahead running. Both are mounted directly on the driving shaft and placed one at each end of the hollow pinion shaft of the reduction gear to which they are also coupled. This shaft is mounted so that it is concentric with the main driving shaft. The astern coupling differs from the ahead coupling, which has two elements, by having a set of stationary symmetrical blades between the two impellers to reverse the direction of flow of the fluid passing from one impeller to the other. The oil used in the hydraulic

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Fig.6. VARIATION OF SPECIFIC FUEL CONSUMPTION WITH LOAD.

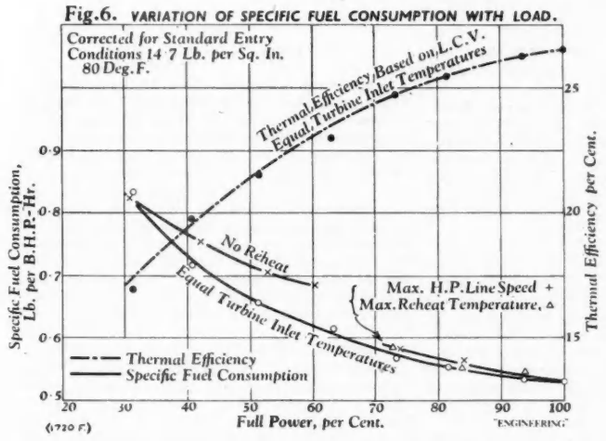
Corrected for Standard Entry Conditions 14·7 Lb. per Sq. In. 80 Deg. F.
Thermal Efficiency Based on L.C.V. Equal Turbine Inlet Temperatures
No Reheat
Equal Turbine Inlet Temperatures
Max. H.P. Line Speed + Max. Reheat Temperature, △
Thermal Efficiency
Specific Fuel Consumption
Specific Fuel Consumption, Lb. per B.H.P.-Hr.
Thermal Efficiency per Cent.
Full Power, per Cent.
(1720 F.)
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Fig.7. WATER ELIMINATOR ELEMENTS

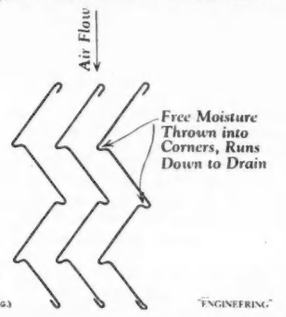


Fig. 8. CROSS-SECTION OF ROTOR BLADE.

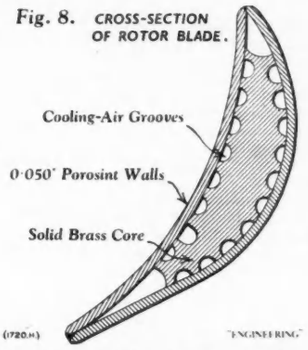
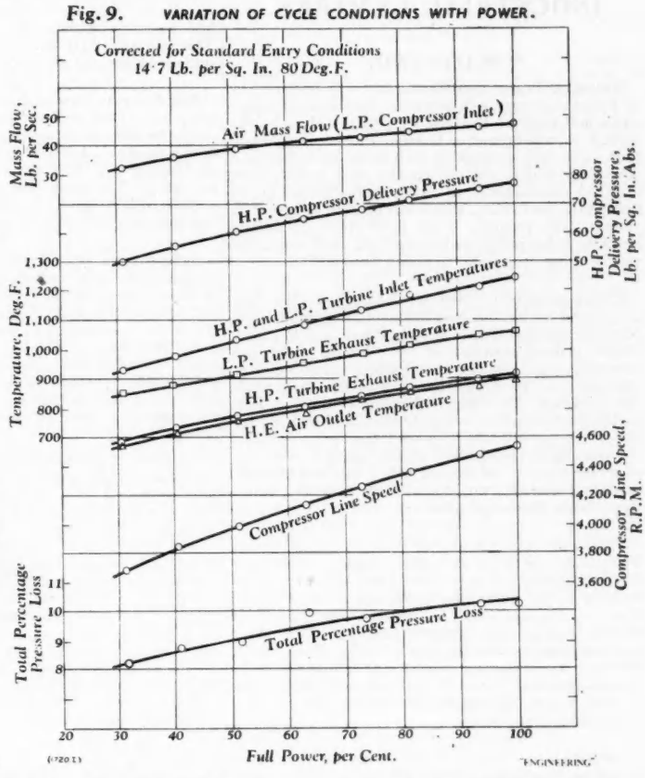


Fig. 9. VARIATION OF CYCLE CONDITIONS WITH POWER.


Corrected for Standard Entry Conditions 14·7 Lb. per Sq. In. 80 Deg. F.
Air Mass Flow (L.P. Compressor Inlet)
H.P. Compressor Delivery Pressure
H.P. and L.P. Turbine Inlet Temperatures
L.P. Turbine Exhaust Temperature
H.P. Turbine Exhaust Temperature
H.E. Air Outlet Temperature
Compressor Line Speed
Total Percentage Pressure Loss
Mass Flow, Lb. per Sec.
H.P. Compressor Delivery Pressure, Lb. per Sq. In. Abs.
Temperature, Deg. F.
Compressor Line Speed, R.P.M.
Total Percentage Pressure Loss
Full Power, per Cent.
(1720 I.)
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couplings is supplied by a boost pump and the feed line has a branch to each coupling. A three-way valve is installed at the junction of the pipeline; by this means the supply can be cut-off or redirected from one coupling to the other. To change from ahead to astern drive takes only a few seconds, a short delay period being allowed for the driven shaft to slow down before going into full drive in the opposite direction. The oil pressure used in the coupling circuit is about 70 lb. per square inch. At present, it is understood, satisfactory results have been obtained when changing from ahead to astern drive, but when a change is made in the opposite direction the rated acceleration is considered to be far too rapid and might result in cavitation occurring in the coupling.

From the information made available there was every indication that all aspects of marine gas-turbine design have or are being considered and Pametrada state the 3,500 h.p. gas-turbine could itself be installed in a ship, but it is considered more desirable that the knowledge and experience gained should be applied to the construction of new units of improved design. The advantages claimed for the use of a marine gas turbine are economy, because fewer auxiliaries than are used on a comparable steam turbine are required; it occupies less space for the same power, and has a lower fuel consumption. The results of the 100-hour run previously mentioned are: horse-power at turbine coupling 3,532; thermal efficiency 27·9; specific fuel consumption 0·505 lb. per brake horse-power per hour as stated; high-pressure turbine outlet temperature 1,242 deg. F., low-pressure turbine outlet temperature 1,284 deg. F., and the compressor line speed 4,650 r.p.m. The atmospheric temperature during the test was 60 deg. F. Figs. 6 and 9 show the results of a complete series of tests to determine full and part load efficiencies with and without reheat.

The gas turbine unit weighs 160 tons, of which the air heater alone weighs 30 tons. The total machinery weight including funnels, ladders, and gratings, spare gear, etc., is about 510 tons, which is stated to be about 140 tons lighter than a direct-coupled Diesel engine developing the same power at 120 r.p.m.

WATER-TREATMENT PLANT AT BUSCOT WATERWORKS.

ON Thursday, September 24, the official opening of one of the most up-to-date water-treatment plants in the country took place at Buscot Waterworks, near Faringdon, Berkshire. The whole plant has been designed, supplied and installed by the Pulsometer Engineering Company, Limited, Reading, the installation forming part of a regional water-supply scheme devised to provide drinking water for the Faringdon area.

Two raw-water pumps draw water from the River Thames into the plant. Both are large single-stage, horizontal, split-casing Pulsometer pumps, one driven by an electric motor and the other by a Diesel engine, and each having a capacity of 1,000 gallons of water per minute. The water is then passed on to large settlement tanks and, during its passage from the pumps to the tanks, the water is treated with chemicals—chlorine to kill bacteria and render the water pure; sulphate of alumina to form a floc in the water which sinks to the bottom of the tank carrying with it suspended impurities which have to be washed away; and activated carbon to remove disagreeable tastes and odours from the water. The water takes some two and a half hours to pass through the settlement tanks. Two small pumps are employed in this chemical treatment, injecting carefully controlled doses at various points of the installation.

The settled water is drawn into a channel and a collecting chamber but at this stage it still contains some very fine suspended matter and a certain amount of alum floc. To extract these, the water is pumped by two large, horizontal split-casing pumps, each capable of handling 1,000 gallons per minute, into a series of twelve 8-ft. diameter Pulsometer vertical cylindrical pressure filters, installed in the main pumping station. These filters can deal with 60,000 gallons of Thames water per hour, each filter shell being filled with a graded medium. The water is forced through this medium and, in passing, the remaining particles and impurities are removed from the water which is then ready to be conveyed to the reservoir for distribution to the consumer.

After receiving the final filtration treatment the water is passed to two main booster pumps, both being of a two-stage split-casing type and capable of delivering 1,000 gallons of water per minute. These booster pumps send the filtered water through a rising main to the Folly Hill reservoir at Faringdon, providing water to Buscot and Eaton Hastings *en route*. As before, one of these pumps is driven by a motor, the other by a Diesel engine. Waste products from the settlement tanks and filters are treated as follows: filter batteries are frequently flushed out by reversing the direction of flow of the water and agitating it with compressed air to remove particles adhering to the sand and gravel. These particles are then piped to the "wash-water" tanks adjoining the settlement tanks. The solid matter is allowed to settle and the top clarified water decanted to a sump to be rejected into the river through a sluice. A sludge pump transfers the sludge to tanks from where it is drained and dug out for removal elsewhere for disposal. The whole process is thus self-contained. Heavily-polluted pungent water is drawn from the river, passed through various stages of purification, filtration and chemical treatment, and distributed in a pure, sparkling and odourless form to the consumer.

EXHIBITION OF MACHINE TOOLS IN OPERATION.—Modern machine tools and equipment will be shown in operation on typical work at a series of demonstrations arranged by Alfred Herbert Ltd., at their London showroom, 70, Vauxhall Bridge-road, S.W.1. These will be held daily from Monday, October 26, to Tuesday, November 3, Sunday excepted, from 10 a.m. to 6 p.m. Machines to be shown at work will include Belsher Seiss-type automatic lathes, Brown and Ward automatic lathes, the Herbert 2D capstan lathe, the Herbert auto-junior chucking machine, the Archdale 20-in. horizontal milling machine, the Scrivener centreless grinding machine, and the Thielicke grinding and lapping machine. Inspection work will be carried out on the Sigma turret comparator and the Sigma automatic multi-dimension machine. These demonstrations will be of particular interest to firms producing small parts for the watch, clock and instrument industries, and to those engaged on general production work on automatic and capstan lathes.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Renfrew Plant and Machinery for Production of Feeding Stuffs.—A new compound animal feeding-stuffs mill built at Renfrew by British Oil and Cake Mills, Ltd., was opened on October 1 by Sir Guy Lloyd, M.P. The mill is equipped with up-to-date plant and machinery and is laid out on the most modern lines designed substantially to raise productivity. In its first phase the factory, which will operate a three-shift system, will produce about 3,500 tons of feeding stuffs in cube, pellet, and overt form each week, but provision has been made to raise this to 5,000 tons.

Developments on Stroma Island.—It has been announced by Mr. Thomas Johnston, chairman of the North of Scotland Hydro-Electric Board, and Mr. A. A. Tabor, general manager of the Scottish Calor Gas Company, that these two organisations have come to an agreement on the formation of a scheme to provide heat and light for Stroma islanders at a cheap rate. As the Board cannot yet supply the island with electricity, Calor gas will take its place temporarily. Another announcement, by Sir David Robertson, M.P., referring to a new harbour for Stroma which will cost 30,000*l*., explained that this would enable the fishermen to use larger boats than at present.

Manufacture of Railway Wagons and Aircraft Fuselages at Paisley.—Mr. Henderson Stewart, Under-Secretary of State for Scotland, visited, on October 1, the works of the Pressed Steel Co., Ltd., Linwood, Paisley, where he saw the manufacture of railway wagons and aircraft fuselages. The latter is a new departure for the firm's Paisley works, and it has been stated that an extensive programme is likely to be embarked upon during the next few years. Railway wagons are produced at the works at the rate of one every 18 minutes.

Opening of Esk Valley College, Newtongrange.—Esk Valley College, Midlothian's first venture in full-time commercial and technical education, was formally opened on October 5 by Mr. Robert Burnside, convener of the County. Situated at Newtongrange, the College is intended to provide courses for the expanding industrial population of Midlothian. Some 70 students are studying mining technology and allied subjects, for the Ordinary National Certificate in Mining, and a further 60 are on practical courses in engineering.

Course on Power-System Plant.—An advanced course on "Power-System Plant" will be available in the Department of Electrical Engineering of the Heriot-Watt College, Edinburgh, on seven successive Saturday mornings from October 24, from 9.30 a.m. until noon. The subjects of the lectures will include, non-salient and salient-pole synchronous generators; load and frequency control of synchronous machines; transformers, reactors and voltage regulators; switchgear principles and practice; underground cables and overhead lines. The fee for the course is 2 guineas and further particulars may be obtained from the secretary, Heriot-Watt College, Chambers-street, Edinburgh, 1.

The Late Mr. J. Simpson.—The death, at Santa Monica, California, of Mr. James Simpson, vice-president of the Douglas Aircraft Company, California, U.S.A., is reported. Mr. Simpson, who was 54, was the eldest son of an Orkney crofter. As assistant plant manager he supervised the manufacture of the Douglas C 124 Globemaster aeroplane.

CLEVELAND AND THE NORTHERN COUNTIES.

Ball-Bearings Factory at Greencroft.—A ball-bearings factory costing well over 1,500,000*l*. has been opened on the Greencroft Estate, Annfield Plain, County Durham, by Ransome and Marles Ltd. The factory, built by North-Eastern Trading Estates, Ltd., Gateshead, has cost nearly 400,000*l*. while equipment worth about 1,250,000*l*. has been installed by the company. The factory, the first to be built on the Greencroft Estate, is also the first major new industry to be started in North-West Durham, where redundancy among miners is expected to increase in future years and new works will be needed to absorb them.

Electricity Supply in North East.—Speaking at a Press conference at Newcastle-on-Tyne to discuss the annual accounts of the North-Eastern Electricity Board, Mr. H. H. Mullens said that it was not proposed, at present, to increase electricity charges, but the stage had been reached when any substantial increases in costs would have to be passed on to the consumer. Mr. Mullens said that, during 1951-52, the Board had had to take 100,000*l*. from their 300,000*l*. reserves. This left only 200,000*l*. which was a very small percentage of the total annual revenue of about 16,000,000*l*.

Ore-Quay at Newcastle.—The million pounds ore-quay being built at Tyne Dock by the Tyne Improvement Commission is to come into operation at the end of this month. A trial shipment of ore is due to arrive on October 19, but there will be no formal opening ceremony. The quay was originally expected to be completed last February, but the constructional work has been delayed owing to steel shortage.

Prospecting for Petroleum in N.E. England.—Imperial Chemical Industries, Ltd., have received a licence to prospect for petroleum in an area covering 142 square miles in Durham and the North Riding of Yorkshire. According to Mr. A. T. S. Zealley, a director of the company, the licence has no special significance. He adds that it is part of the company's normal exploration for gases or chemicals which might be useful, and does not mean that the I.C.I. believe that there are quantities of oil in the area concerned.

Industrial Developments in the North East.—The Sunderland Corporation Highways Committee have approved plans for extending the heavy machine shop at the Pallion Shipyard of William Doxford and Sons, Ltd. The extension will result in a large increase in the production of Doxford engines. Newcastle-on-Tyne City Council have been recommended by the Trade and Commerce Committee to spend 63,710*l*. on the purchase of one ten-ton and three six-ton electric travelling cranes for Newcastle Quay. The cranes are to help in the rapid unloading and loading of ships at the quay. Preparations are in hand for installing two pumps at Chilton Colliery, County Durham, to clear the lower workings of water, and also to make more coal available for working at the nearby Dean and Chapter Colliery and Mainsforth Colliery.

The Late Mr. W. H. Saxton.—The death has taken place suddenly of Mr. William Harley Saxton, resident civil engineer at the new Lackenby Steel Works of Dorman, Long & Co., Ltd. Middlesbrough. He was born at Sheffield and received his technical education at the University of Sheffield, where he obtained the B.Eng. degree. Mr. Saxton took up an appointment with Dorman, Long & Co., before the 1914-18 war. Later he was with Armstrong, Whitworth & Co., Ltd., but for the past 20 years had been with Dorman, Long's constructional department. Mr. Saxton was a past chairman of the Northern Counties branch of the Institution of Structural Engineers, of which he was a member for a number of years.

LANCASHIRE AND SOUTH YORKSHIRE.

Visit of Nigerian Administrators to Manchester.—A party of 18 Nigerian African administrators recently spent a week in Manchester as part of a two-month study of the British way of life. Included in their itinerary was a tour of the Salford works of David Brown-Jackson, Ltd., on Tuesday, October 6, during which time they saw the cutting of gears weighing up to ten tons, and were particularly interested in the tapping of a 10-ton furnace and the subsequent pouring of a large gear casting. The party included local-government officials, teachers and agricultural supervisors. The visit was financed by the Nigerian authorities, and had been arranged under the auspices of the British Council.

Employment Improving in South Yorkshire.—The Sheffield and District Employment Committee reports that the unemployment level in Sheffield is 0·5 per cent. below the national rate, and is steadily improving. On the last day of the quarter ended August 28, there were 1,598 unfilled vacancies or over 100 more than at the end of the previous quarter. Upwards of 1,000 men and 62 women were placed in employment in the iron and steel industries. There were 130 unfilled vacancies in the engineering industry, including 26 places for women, but all were for highly skilled persons.

Air Pollution.—The Sheffield Medical Officer of Health, Dr. L. Roberts, reports that records show that domestic pollution of the air is only half that caused by industry. Metallurgical-process chimneys, he states, cause the greatest amount of pollution and, unfortunately, these chimneys are provisionally exempted from the Public Health Act. Dr. Roberts adds that provided the right type of controlled furnace is used there is no need for the atmosphere to be polluted. Reconstruction is going on, but there is need for acceleration of recon struction and the provisional exemption should be repealed.

THE MIDLANDS.

Electricity Charges.—The Midlands Electricity Board announce that, as from October 1, electricity charges to commercial and domestic consumers will be increased. This is the fourth increase since 1948, and is required to raise an additional 1,000,000*l*. needed to balance the Board's accounts.

Quarrying at Malvern, Worcestershire.—The result of recent decisions by the Minister of Housing and Local Government is that quarrying in the Malvern Hills, Worcestershire, a celebrated local beauty spot, will be reduced progressively, and finally stopped altogether. Quarrying for roadstone has been carried on there for more than a hundred years.

New Midland Omnibuses.—The Birmingham and Midland Omnibus Co., Ltd. (the Midland "Red"), are introducing new lightweight vehicles of stressed-skin construction, which have numerous other new features, including disc brakes. The vehicles have been designed by the company, and will be built at their works at Carlyle-road, Edgbaston, Birmingham, 16. The production of the first batch of 270 omnibuses will commence early next year.

Metal Company's Jubilee.—The Wolverhampton Metal Co., Ltd., Wednesfield, Staffordshire, celebrate their Jubilee this month. The business was founded in 1903 by six brothers, of whom Mr. T. C. James, the present chairman and managing director, is the sole survivor. The Wolverhampton Metal Co. started with four employees, and now have over 1,000. One of their best-known activities since the war has been the salvage of the wreck of H.M.S. Warspite, which went ashore on the Cornish coast in 1947.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Industrial Position in South Wales Development Area.—Sir Percy Thomas, chairman of the Welsh Board for Industry, told a meeting of the Board held at Cardiff last week that an informal talk had been arranged between representatives of the Board and the Vice-Chancellor of the University of Wales to obtain information regarding the demand for graduates in the engineering industry in Wales. After the meeting of the Board, Capt. H. K. Oram, Controller for the Board of Trade in Wales, announced that there had been only two cases of withdrawal of firms occupying Government factories in the South Wales development area. This was an indication, he said, of the strength of the new industries.

Welsh Steel Industry.—The output of steel ingots and castings in Wales during the four weeks of July, 1953, was 298,000 tons, compared with 362,000 tons in the five weeks of July last year. This represented an increase of 2·7 per cent. this year in the annual rate of output. The output of sheet steel in July was 72,363 tons, against 92,579 tons in 1952, a decrease in the annual rate of 2·29 per cent. The output in tin-plates was 50,076 tons against 83,861 tons in July, 1952, a decrease of 25·35 per cent. The improving market for tin-plates, however, may soon lead to increased production of this commodity.

Exports of Steel Products.—When a party of shipowners and industrialists toured Cardiff Docks and industries as guests of the Port Development Association, Mr. N. R. R. Brooke, managing director of Guest, Keen and Nettlefolds (South Wales), Ltd., said that from the Tremorfa and Castle works at Cardiff the Company had already exported well over 1,000,000*l*. worth of goods this year. They did business all over the world but in the past six months they had been doing a very big business with the United States. There had been very great competition from Europe and Japan for their steel products and it had not been easy to do business.

The Coal Industry and Coal Exports.—Sir Herbert Merrett, chairman of Powell Duffryn, Ltd., in a statement issued to shareholders, states that the National Coal Board has an enormous task in hand but that its progress is too slow and expenditure on modernisation is behind time. It is to be hoped that appeals now being made for greater effort and increased production per man employed will be more fully appreciated by those who have in their hands the well being of the greatest of the national industries and, to a large extent, the control of the country's trade balance.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, October 19, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Informal Meeting. Discussion on "Television." *Mersey and North Wales Centre:* Monday, October 19, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Joint Meeting with the LIVERPOOL ENGINEERING SOCIETY. "Design Features of Certain British Power Stations," by Mr. S. D. Whetman and Mr. A. E. Powell. *District Meetings:* Monday, October 19, 7.15 p.m., George Hotel, Reading. "Use of Artificial Irradiation in Horticulture," by Professor R. H. Stoughton. Wednesday, October 21, 7 p.m., 37, George-street, Oxford, "Use of Aluminium in the Electricity Supply Industry," by Mr. A. Gregory. *Measurements Section:* Tuesday, October 20, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Chairman's Address, by Mr. J. F. Coales. *East Midland Centre:* Tuesday, October 20, 6.30 p.m., Gas Board's Showrooms, Nottingham. "Lightning Surges," by Dr. R. H. Golde. *Southern Centre:* Wednesday, October 21, 6.30 p.m., Southern Electricity Board's Showrooms, Salisbury. "Electricity in Farm Crop-Drying," by Mr. C. A. Cameron Brown and Mr. F. G. Finn-Kelcey. *Utilization Section:* Thursday, October 22, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Chairman's Address, by Mr. B. L. Metcalf.

SOCIETY OF CHEMICAL INDUSTRY.—*Corrosion Group:* Monday, October 19, 6.30 p.m., Chemical Society's Apartments, Burlington House, Piccadilly, W.1. (i) "Phosphating of Steel Prior to Painting," by Mr. H. A. Holden; and (ii) "Protective Properties of Various Phosphate Coatings on Steel," by Mr. J. F. Andrew, Dr. S. G. Clarke and Dr. E. E. Longhurst.

INSTITUTE OF PACKAGING.—*Midland Area:* Monday, October 19, 6.30 p.m., Imperial Hotel, Birmingham. "Packaging for Retail Sale of Pharmaceuticals," by Mr. E. Richardson.

INSTITUTION OF PRODUCTION ENGINEERS.—*North-Eastern Section:* Monday, October 19, 7 p.m., Neville Hall, Newcastle-upon-Tyne. "Lighting for Production," by Mr. H. B. Topham. *Oxford Section:* Monday, October 19, 7.15 p.m., Randolph Hotel, Beaumont-street, Oxford. "Blanket Manufacture," by Mr. D. J. Smith. *Manchester Section:* Monday, October 19, 7.15 p.m., College of Technology, Manchester. "Manufacture and Application of Fibre Glass," by Mr. J. B. Mitford. *Birmingham Section:* Wednesday, October 21, 7 p.m., James Watt Memorial Institute, Birmingham. "Value of Work Study to Industry," by Mr. W. H. Hodgetts. *Coventry Section:* Thursday, October 22, 7 p.m., Sibree Hall, Warwick-row, Coventry. "Aircraft Production Development," by Mr. W. A. Sales.

INCORPORATED PLANT ENGINEERS.—*Merseyside and North Wales Branch:* Monday, October 19, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Design of a Central-Heating System," by Mr. N. Woodhead. *South Wales Branch:* Tuesday, October 20, 7.30 p.m., Mackworth Hotel, Swansea. Discussion on "Lubrication." *Glasgow Branch:* Wednesday, October 21, 7 p.m., 425, Sauchiehall-street, Glasgow. "Fire Prevention," by Mr. M. Chadwick. *Kent Branch:* Wednesday, October 21, 7 p.m., Bull Hotel, Rochester. "Heat Recovery from Oil Engines," by Mr. N. Halliwell. *Western Branch:* Wednesday, October 21, 7.15 p.m., Grand Hotel, Bristol. "Engineering Aspects of Water Supply," by Mr. R. W. Melvin.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS and IRON AND STEEL INSTITUTE (*Engineers' Group*).—Monday, October 19, 7.30 p.m., University, St. George's-square, Sheffield. "Control Valves for Direct Hydraulic Presses," by Mr. F. H. Towler.

INSTITUTION OF THE RUBBER INDUSTRY.—*Leicester Section:* Monday, October 19, 7.30 p.m., Bell Hotel, Leicester. "Synthetic Resins in Rubber," by Mr. J. E. S. Whitney.

INSTITUTE OF REFRIGERATION.—Tuesday, October 20, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Insulation Testing," by Dr. H. Stafford Hatfield and Mr. L. A. Smith.

INSTITUTION OF CIVIL ENGINEERS.—*Hydraulics Engineering Division:* Tuesday, October 20, 5.30 p.m., Great George-street, S.W.1. "Measurement and Utilisation of the Water Resources of the Nile Basin," by Dr. H. E. Hurst. *Yorkshire Association:* Wednesday, October 21, 6.15 p.m., Electricity Board's Showrooms, Hull. Chairman's Address, by Mr. D. Currie. *Midlands Association:* Wednesday, October 21, 7 p.m., Loughborough College, Loughborough. Chairman's Address, by Mr. T. H. P. Veal.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 20, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Standardisation of Diesel-Electric Power Packs," by Mr. J. C. Macfarlane, Dr. J. W. Macfarlane and Mr. W. I. Macfarlane.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, October 20, 6.30 p.m., 2, Savoy-hill, W.C.2. Presidential Address on "Education and Training in the Electrical Industry," by Mr. C. T. Melling. *Nottingham Branch:* Wednesday, October 21, 7.30 p.m., East Midlands Electricity Board's Showroom, Nottingham. "High Frequency and Its Application in Industry," by Mr. J. E. Kosier.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, October 21, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. Various short papers.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, October 21, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Production of Steel Wagons," by Mr. W. Vandy.

INSTITUTE OF FUEL.—*Yorkshire Section:* Wednesday, October 21, 6.30 p.m., The University, Leeds. "Grit and Dust Collection from Industrial Chimneys," by Mr. J. C. Cleeves.

INSTITUTION OF MECHANICAL ENGINEERS.—*Midland Branch:* Wednesday, October 21, 6.30 p.m., College of Technology and Arts, Rugby. "A Photoelastic Study of Stresses in Screw Threads," by Mr. A. F. C. Brown and Mr. V. M. Hickson. *Eastern Branch:* Wednesday, October 21, 7.30 p.m., Dujon Restaurant, Bedford. Joint Meeting with the INSTITUTION OF PRODUCTION ENGINEERS (*Luton Section*). "Aspects of Machineability," by Mr. J. Cherry. *North-Western Branch:* Thursday, October 22, 6.45 p.m., Engineers' Club, Manchester. Discussion on "The Machine Tool Productivity Report," opened by Mr. J. Houldsworth. *Institution:* Friday, October 23, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Special General Meeting (Corporate Members only). *Southern Graduates' Section:* Friday, October 23, 7.30 p.m., Technical College, Brighton. Annual Lecture on "Industrial Power Engineering and Fuel Conservation," by Mr. John Fox. *Automobile Division, Scottish Centre:* Monday, October 19, 7.30 p.m., 39, Elmbank-crescent, Glasgow. Chairman's Address on "Combustion in Compression-Ignition Oil Engines," by Prof S. J. Davies.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—*Student Section:* Wednesday, April 21, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne. Chairman's Address on "Crew Accommodation in the Last Thirty Years," by Mr. G. A. Smith.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, October 21, 6 p.m., London School of Hygiene, Keppel-street, W.C.1. Annual Meeting. 7 p.m. "Printed Circuits: Principles and Applications of Foil Technique," by Dr. Ing. P. Eisler.

INSTITUTION OF WORKS MANAGERS.—*Tees-Side Branch:* Wednesday, October 21, 7.30 p.m., Vane Arms Hotel, Stockton-on-Tees. "Engineering Problems in Switzerland," by Mr. H. Bauer.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*North-West Centre:* Wednesday, October 21, 7.30 p.m., Victoria Hotel, Wigan. "The Port of Liverpool," by Mr. D. Gilmour. *Institute:* Thursday, October 22, 6.30 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Filtration for Road-Transport Vehicles," by Mr. E. A. Stokes.

INSTITUTE OF COST AND WORKS ACCOUNTANTS.—Thursday, October 22, 5.30 p.m., Beaver House, Great Trinity-lane, E.C.4. Public Meeting. Discussion on "Cost Accounting and Productivity."

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, October 22, 6 p.m., Joint Meeting with the BRITISH IRON AND STEEL RESEARCH ASSOCIATION and the IRON AND STEEL INSTITUTE (*Engineers' Group*). "Crane Gantry Girders for Steelworks," by Mr. J. S. Terrington and Dr. J. M. Hawkes. *Midland Counties Branch:* Friday, October 23, 6 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address, by Mr. G. E. Marsden.

TELEVISION SOCIETY.—Thursday, October 22, 7 p.m., Cinematograph Exhibitors' Association, 164, Shaftesbury-avenue, W.C.2. "Flywheel Synchronising and Scanning Circuits," by Mr. H. Fairhurst.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Scottish Branch:* Thursday, October 22, 7.15 p.m., University College, Dundee. Joint Meeting with DUNDEE INSTITUTE OF ENGINEERS. "The Future of Cast Iron," by Mr. J. Cameron, Jun. *Bristol and West of England Branch:* Saturday, October 24, 3 p.m., Offices of T. H. and J. Daniels, Ltd., Stroud. Film: "Castings for Internal-Combustion Engines," presented by Mr. C. R. van der Ben and Mr. H. Haynes.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE.—Friday, October 23, 6.45 p.m., 39, Elmbank-crescent, Glasgow, C. 2. Presidential Address, by Mr. A. McKendrick.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 23, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Waste Heat Recovery as Applied to Diesel Engines," by Mr. R. M. Tufnell.

PERSONAL.

SIR JOHN HACKING, M.I.E.E., has decided to relinquish his appointment as deputy chairman (operations) of the BRITISH ELECTRICITY AUTHORITY, on reaching the age of 65 on December 16, 1953.

CAPTAIN K. J. G. BARTLETT, C.B.E., who recently reached the age of 60 and has completed 25 years of service with the Bristol Aeroplane Co. Ltd., Filton, Bristol, has relinquished his executive appointment as sales director of the company, but is retaining his seat on the board.

G. and J. Weir, Ltd., Cathcart, Glasgow, announce that MR. J. M. DOUGLAS has been appointed managing director of the Argus Foundry Ltd., Thornliebank, as from September 30.

MR. J. W. ELLIOTT, C.B.E., F.C.I.S., chairman of Swan, Hunter, and Wigham Richardson Ltd., Wallsend-on-Tyne, has been elected President of the Shipbuilding Conference in succession to MR. CHARLES CONNELL, M.A. DR. JAMES M. MCNEILL, C.B.E., M.C., M.I.N.A., F.R.S., deputy chairman and managing director of John Brown & Co. (Clydebank) Ltd., has been elected vice-president.

MR. H. A. AITKEN, who has been district manager, Buckhaven and Leven, Fife Group, Central Division, Scottish Gas Board since 1922, has retired after nearly 50 years of service in the gas industry. He was President of the North British Association of Gas Managers from 1938 until 1940.

Thermotank Ltd., Glasgow, announce the following appointments which are effective from October 1. As vice-chairman, MR. D. D. BLACKWOOD; as general manager, MR. J. K. W. MACVICAR; as director, engineering division, MR. G. B. PERRY; as director, marine installations, MR. A. MCCUTCHION; as director, marine design, MR. S. FAIRWEATHER; and as London director, MR. S. F. JONES.

MR. E. N. WRIGHT, managing director of Ernest N. Wright Ltd., Millfields, Wolverhampton, since its incorporation in 1919, has retired.

MR. R. D. GLASS, production director of the Northern (Northumberland and Cumberland) Division of the National Coal Board, is resigning his position at the end of this year to take up an appointment in South Africa.

MR. C. D. MORGAN, F.C.I.S., F.R.S.A., has been appointed secretary of the British Road Federation, 4A, Bloomsbury-square, London, W.C.1, in succession to MR. A. A. E. MORGAN, A.C.A., who has resigned to take up an industrial appointment.

G.P.U. LTD. and their subsidiary organisation, the ELECTROPLANT CO., announce that they have moved their headquarters from Wembley to their new West-End office, 44, Bryanston-street, London, W.1, to which address all communications should be sent. Their works and stores have been transferred to their associated firm, H. Fisher (Oldham) Ltd., Oldham, Lancashire.

The Manchester office of the ENGLISH ELECTRIC CO., LTD., Stafford, has been transferred to Croxley House, 14, Lloyd-street, Deansgate, Manchester, 2. (Telephone: Deansgate 7872/6.)

The telephone number of the BRISTOL AEROPLANE CO., LTD., Filton, Bristol, has been changed to Filton 3831; and the telephone numbers of the company's London office, 6, Arlington-street, St. James's, S.W.1, to HYDe Park 0957/8 and 3941/4.

TUBE INVESTMENTS LTD., The Adelphi, London, W.C.2, have acquired the whole of the shares of the ROUND OAK STEEL WORKS, Brierley Hill, Staffordshire. In all, the payment of sums totalling over 5,803,000*l.* is involved. It is intended that the Works shall continue to produce the special types of steel associated with the establishment and, in particular, that the supply of tube steels will be increased to make good existing shortages.

A new company is being formed in Britain by the ALLIS-CHALMERS MANUFACTURING CO., Milwaukee, U.S.A., to take over their assets in the United Kingdom as from December 1, 1953, in exchange for shares. The new company will handle Allis-Chalmers products in the United Kingdom, as well as exports to markets conveniently served from this country. The directors will include MR. W. A. ROBERTS, chairman and President of the parent company; MR. E. J. MERCER, managing director, at present general manager of the firm's British branch; and MR. M. M. TULLOCH, at present London manager of the General Machinery Division.

WICKMAN LTD., Coventry, have concluded agreement with Maskinfirma R. L. Carlstedt Bradstupsvagen, of Stockholm, Sweden, and Maschinenfabrik Weingarten A.-G., of Weingarten-Wurttemburg, Germany, to represent them as sole agents in the United Kingdom.

MOXEY CONVEYOR AND TRANSPORTER CO. LTD., have removed their head office to 13, Augustus-road, Birmingham, 19 (Telephone: EDGbaston 3575), and their stores to 19, Lionel-street, Birmingham, 3, (Telephone: CENtral 2828.)

3,500-H.P. MARINE GAS TURBINE.

PAMETRADA, WALLSEND-ON-TYNE.

(*For Description, see Page* 491.)

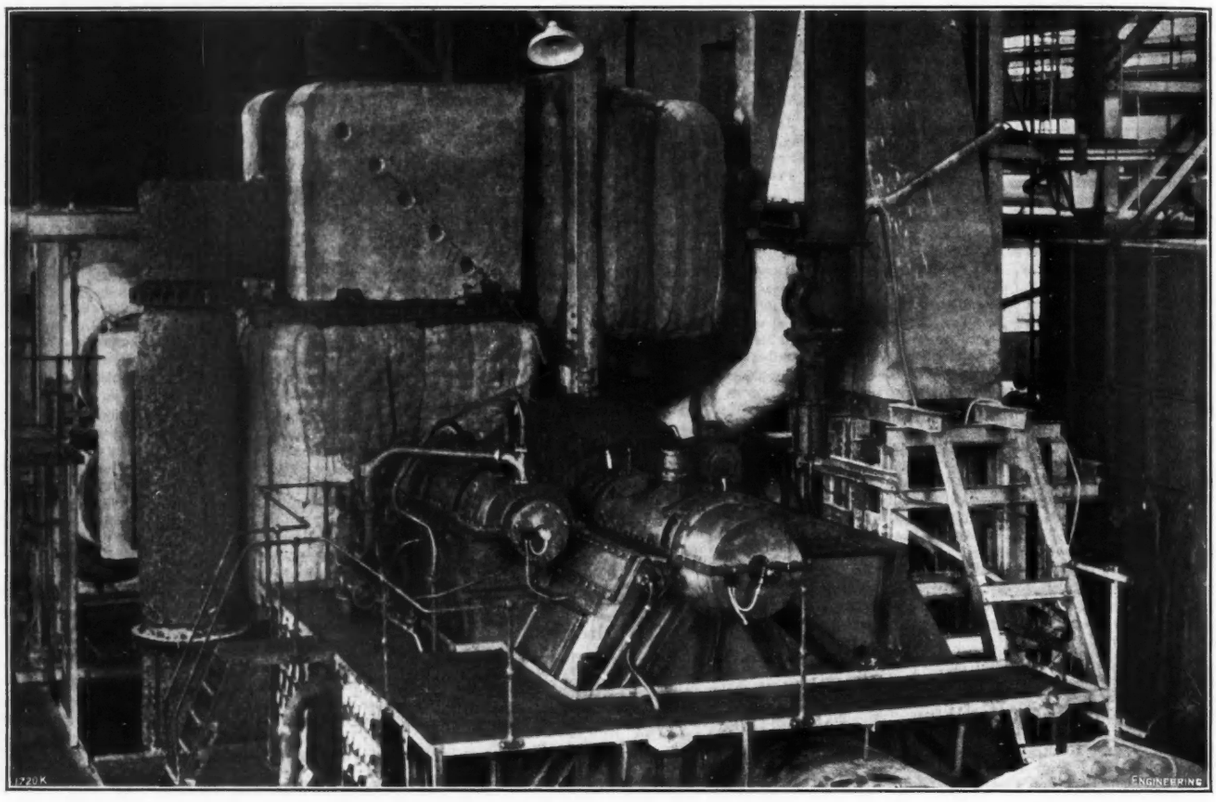

Fig. 10. Marine Gas Turbine viewed from Driving End.

Fig. 11. Modifications to Compressor Entry.

Fig. 12. Modifications to Compressor Outlet.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, OCTOBER 16, 1953.

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SMOKE ABATEMENT.

ON January 11, 1662, John Evelyn received from "the Queen's Attorney the draft of an Act designed to reduce the smoke nuisance in London by providing for the removal of several trades which were the cause of it, and which endangered the health of the King and his people." On October 1, 1953, Dr. J. A. Scott, Medical Officer of Health of the London County Council, suggested "the cessation of industrial activity . . . when a fog seems likely." In the days of Evelyn nothing was known about efficient combustion and it may be surmised that the "sea coal" in use was burned in a very crude way. Much is now known, but it does not appear to have greatly modified general practice, and after 291 years London is faced with the same problem with which Evelyn was concerned.

How serious atmospheric pollution was at the time of John Evelyn cannot now be known. His own description was picturesque: he referred to the "hellish and dismal cloud of sea-coal which maketh the City of London resemble the suburbs of Hell." In case it should be thought an exaggeration to carry over this description to the present day, it may be pointed out that the London fog which lasted from the 5th to the 8th of December, 1952, is authoritatively reported to have been the direct cause of 1,500 deaths in the Administrative County and 4,000 among the 8½ million population constituting Greater London. This matter attracted a certain amount of public attention but nothing like as much as the East Coast floods of last January, with their much smaller loss of life.

It is the business and purpose of the National Smoke Abatement Society both to educate public opinion to an appreciation of the importance of the atmospheric pollution problem, and, as far as its limited funds allow, to assist towards a wider use of smoke-prevention appliances. The latest public activity of the Association has been the holding of its annual conference in Glasgow. The proceedings extended over three days—September 30 to October 2—and a series of papers were presented which reviewed the extent of the suffering and damage caused by smoke and the various appliances and methods available for its reduction.

The report by Dr. A. Parker, Director of the Fuel Research Station, on "The London Fog Disaster" constituted an important contribution to the proceedings. He pointed out that fog was a natural phenomenon caused by inversion of the normal temperature conditions in the atmosphere and that there was no known economic method of preventing or dispersing it. The London fog of December, 1952, varied greatly in the depth of its layer; Hayes Common in Kent, at an altitude of 250 ft., was clear of fog for the whole of the period, while to the north, as far out as St. Albans, hills 400 ft. high were completely covered. At one time, in Blackheath, at an altitude of 160 ft., the tops of 'buses could be seen above the fog. Observations at Kew and Kingsway showed that there was practically no wind and the temperature was relatively low. In these circumstances, smoke and other finely-divided particles discharged from domestic and industrial chimneys at heights less than a few hundred feet could not be dissipated or diluted, with the result that the pollution at ground level rose to an unusually high figure.

These observations do not solve the problem; they indicate that the only way in which it can be solved is by ceasing, or greatly reducing, the discharge of deleterious matter. The conditions of last December may be reproduced in any coming winter. Dr. Parker gave some figures for the extent of the pollution. The concentrations at 12 recording stations varied from 103 to 375 milligrammes of smoke per 100 cubic metres, and 47 to 107 parts of sulphur dioxide per 100 million, or about five times the concentrations of the three days before the fog. At the County Hall, 446 milligrams of smoke per 100 cubic metres and 134 parts of sulphur dioxide per 100 million were recorded. Dr. Parker referred to carbon monoxide, which did not appear to be mentioned by other speakers. No measurements were made of this substance but it seems highly probable, as he suggested, that in some areas, particularly where there was much slow-moving motor traffic, concentrations may have become seriously high. It may have been partly responsible for the high death roll.

As fog is a natural phenomenon which cannot be controlled, the practical problem presented is how to prevent the relatively pure whitish mist of country districts from becoming the "smog" of built-up and industrial areas. The relative contributions to atmospheric pollution by the two main sources of smoke—domestic fires and industrial furnaces—naturally vary in different towns and areas. Nearly twenty years ago, the late Dr. J. S. Owens stated that it had been estimated that in London the smoke from domestic fires was about 2½ times as great as that from industrial furnaces, but in a paper presented at the conference by Dr. F. J. Eaton, Mr. G. E. Hall and Mr. I. Jacob, Dr. Parker was quoted to the effect that domestic open fires accounted for about "half the total from all uses." These estimates cannot be based on definite data, but even if exact figures were available they would not be of particular value. Importance lies in the qualitative statement that domestic fires are a major contributor to the smoke nuisance.

The last twenty years have seen great progress in the development of both domestic and industrial fuel-burning appliances. Their utilisation in indus-

try has been fostered by the publications of the Fuel Efficiency Committee of the Ministry of Fuel and Power, by Post War Building Studies and other documents. With the present high cost of all fuels, it might be expected that the activities of large industrial users would be conditioned by what economists call the "price mechanism," but it was stated in the paper by Dr. Eaton and others, already referred to, that "much can still be done to stop fuel waste" by the "small industrial user, where the size of the unit does not justify the expense of a fuel engineer." On the whole, the conference paid more attention to the domestic rather than the industrial smoke problem, but there was a useful paper by Mr. K. H. Sambrook on "The Efficient and Smokeless Combustion of Fuel Oils," which was chiefly concerned with the industrial sphere. He pointed out that although fuel oil was generally accepted as being a smokeless fuel, it would produce considerable smoke if it was not burned properly.

For the domestic user, an extensive range of stoves and fires has been introduced in recent years. They are designed to burn both bituminous coal and coke, and, presumably, smokeless fuels. They are claimed to result in considerable fuel saving but "smokelessness can only be achieved by the use of smokeless fuels." Smoke will be produced by bituminous coal, particularly when lighting or banking-up fires, and although Dr. Scott permitted himself to describe "nutty slack" as an abomination, it and other bituminous coals will continue to be used until smokeless fuels are available in adequate quantity and at attractive prices. In a paper entitled "Availability and Distribution," presented jointly by Messrs. C. Buist, J. O. Cooke, E. J. David and H. H. Prosser, some information was given on this subject. The annual post-war consumption of house coal has been of the order of 35 million tons and the total weight of solid smokeless fuels now being supplied to the domestic market is 5·22 million tons per year. Of this, 2·50 million tons are gas coke. Low-temperature coke—Coalite and Rexco—particularly suitable and attractive for many modern domestic fires, total only 0·42 million tons. The National Smoke Abatement Society has no power to control the production of smokeless fuels, but clearly it must be greatly increased if the Society's objects are to be attained.

The other aspect of the problem is the cost of the improved domestic appliances. It is said that 2¼ million fires were purchased by British householders in 1952, but it is not clear if this figure related to the comparatively-simple so-called "openable stoves" fitting into existing grates, or to the total of every type of new appliance, including convection stoves with back boilers. No doubt a substantial proportion of the modern appliances were fitted into new houses. Some figures which are given suggest that an individual house-owner may consider the cost of conversion rather high even though the new appliance will reduce his fuel consumption. Supplying and fixing the "improved open fire" costs about 5*l*. in London, but the average cost of 680 installations in Birmingham covering a combination grate and back boiler was 70*l*. In an informative paper dealing with smokeless zones, Dr. T. Morrison Clayton, Medical Officer of Health for Coventry, stated that in the Act obtained by Salford for the setting up of a smokeless zone, it was provided that a compensation payment for conversion up to a maximum of 2*l*. per house was provided for. This will obviously be an assistance but will be far from covering the cost of many, or most, revised installations. Domestic pollution is evidently being reduced by the growing use of gas and electric appliances, but solid fuel will long continue to be used in domestic premises. A practical way of dealing with the situation lies in the setting-up of smokeless zones; these set an example and furnish direct evidence to the general public of the value of reducing its own addition to the smoke of towns.

ECONOMY IN POWER STATION CONSTRUCTION.

It is a trite, but none the less true, saying that the economic survival of Great Britain depends on its industrial efficiency. It is equally true that to secure this efficiency industry must have an adequate supply of cheap power and that, as a corollary, a very heavy programme of power station construction will be necessary. Unless, however, due economy is exercised in carrying out this construction, a serious burden will be laid on national resources and costs will be increased. It was therefore wise of the Minister of Fuel and Power, about a year ago, to appoint a committee, under the chairmanship of Sir Hugh Beaver, "to consider in the light of present economic and supply difficulties whether any savings of materials or man-power can be introduced into the planning, designing and construction of power stations and in particular, in regard to the scarce materials, steel, timber, bricks, cement, etc." This Committee has now issued its report* in the shape of a document which is well worth reading for its own sake and should certainly be studied by all those engaged in this branch of engineering.

The primary objective in the appointment of the committee was, as has been said, to secure economies in building materials and labour. Actually, however, the 1952 programme of the British Electricity Authority was estimated to call for only 1 per cent. of the national annual output of bricks, 2 per cent. of the annual output of cement, and 1 per cent. of the civil engineering and building labour. It was therefore solely in the case of structural and reinforcing steel, the consumption of which was 16 per cent. of the whole, that disturbances to other users might have been felt; and in any event, this material is not much employed in the building of houses. The committee therefore wisely decided to interpret their terms of reference on the broadest lines and to direct their attention to the problems of power-station construction as a whole.

It has been unkindly remarked that it is now customary to build power stations like cathedrals and cathedrals like power stations. The committee have, however, not taken this pleasantry too seriously, but have undertaken their task realistically, as is shown by the statement that "a power station is merely the housing of a power producing unit." They have therefore first considered the size and volume of the power unit and then its siting before dealing with its accommodation. In connection with siting, they point out, as has so often been done before, the difficulties first of discovering suitable land and then, owing to the numerous authorities which have to be consulted, the delays incurred in building. In the case of a station at Fleetwood, for example, eight sites were surveyed and found suitable by the Authority before one could be finally used. This sort of procedure costs money, and we heartily agree with the recommendation that the present arrangements for finding and approving sites should be reconsidered without delay.

Ultimately, of course, the construction of a power station building depends upon the plant it is required to contain. Although some advance in standardisation of the main plant, especially in the greater use of "unitisation," has been made, the Committee are convinced that more simplification, both in layout and in the design of equipment, is possible. This simplification would lead to reductions in cost, in material and time of construction and is therefore worth some considerable effort to obtain. They consider it possible, for instance, to have a standard design for the building and layout of the generator house for a given size of turbo-alternator from any one maker; and even to attain a measure of standardisation along the same lines in the boiler house. If this were done it would further be possible to standardise the leading dimensions of such items as fans, fuel tanks, electrostatic precipitators and chimneys, as well as of valves, pipe flanges and small motors. Such rationalisation would have an important bearing on the speed of designing and constructing the building and would thus, in itself, make for economy. There is also scope for real economy in the provision of ancillary facilities, such as cranes.

These various considerations, not all of which are of course new, have an inevitable effect on the size and overall cost of the buildings housing the plant. In the past, 60 cub. ft. of covered space per kilowatt installed has not been unusual for this purpose, and this at present prices would cost 12*l*. million per 1,000 MW installed. As is pointed out, it is essential to cut down this figure, and it is satisfactory to learn that a progressive reduction is taking place. In fact, whereas in the years from 1945 to 1947 the weighted average of building volume was 56 cub. ft. per kilowatt, from 1948 to 1952 it had fallen to 46 cub. ft. for stations housing 30-MW sets and to as little as 26 cub. ft. per kilowatt for stations in which 100-MW units were being installed. This reduction is ascribed to many factors, including the introduction of larger units; and a further improvement, to only 17·5 cub. ft. per kilowatt, is expected in two new stations where the boiler plant will be erected in the open air. In this connection it is recommended that designers should base their work on a life of 30 rather than 100 years, both as regards the main elements of the structure and the details and finish. Costs could also be reduced by paying closer attention to functional and economic factors in design, special mention being made of fuel-handling equipment and bunker construction.

The considerations we have summarised naturally lead up to the problem which was explicitly stated in the Committee's terms of reference—the design of the civil engineering works and buildings. These works in a modern power station may account for one-third of the total cost, a proportion which in the past has in varying degrees been due to conservatism, a desire to erect structures of impressive appearance and exceptional quality and durability, to over-design of those parts of the work which is exposed to risk, however remote, and to excessive expenditure on labour-saving devices. This is a formidable indictment, and it is only right to add that matters have recently improved and will doubtless improve even more in the future now that the Authority have adopted a policy on architectural design which should make for lighter and simpler construction and enable new materials to be used to a greater extent. This part of the report will be read with a wry interest as it discloses past mistakes. Its main purpose should, however, be to illustrate what is to be avoided.

In a final section it is stated that the present method of carrying out construction is far from ideal. This arises partly from the different forms of contract which were in use on the vesting date; but the position should therefore be improved now that a uniform system has been adopted. Economies may also be expected when the proposed policy of letting the building and civil engineering work to one contractor is implemented, and the application of the same policy to certain portions of the equipment might have the same result. This should in turn lead up to the ideal method of carrying out large constructional work—identity of action and interest from the outset in the planner, the designer and the contractor. The report contains a number of comparative figures and diagrams, which should be read in conjunction with the text. The whole forms a contribution to the problem of power-station design from an unusual and useful aspect

* *Report of the Committee of Enquiry into Economy in the Construction of Power Stations.* H.M. Stationery Office. [Price 2*s*. net.]

NOTES.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

THE inaugural meeting of the Institution of Electrical Engineers was held in the lecture theatre of the Institution building on Thursday, October 8, Colonel B. H. Leeson being in the chair. After welcoming a number of new corporate members and presenting the premiums awarded during the previous session, the chairman introduced the new President, Mr. Harold Bishop, C.B.E., B.Sc. (Eng.) and invited him to deliver his inaugural address. As Mr. Bishop is Director of Technical Services of the British Broadcasting Corporation it is natural that his address was largely concerned with the development of the broadcasting service in this country, but it concluded with a section commenting on the subject of the recruitment and training of entrants to the electrical engineering profession and industry. We hope to print a summary of the address in an early issue. A vote of thanks for the address, proposed by Sir Noel Ashbridge and seconded by Mr. S. E. Goodall, was put to the meeting by the chairman and carried by acclamation. After a brief acknowledgment by Mr. Bishop, Colonel Leeson vacated the chair in favour of Mr. Bishop, who called upon Sir John Hacking to propose a vote of thanks to the retiring President. This was seconded by Mr. J. Eccles and duly carried. Colonel Leeson responded and was presented with the customary Presidential Certificate. After the meeting, the Council dinner was held at the restaurant of Simpsons in the Strand, and was attended by a large number of guests.

THE INSTITUTION OF PRODUCTION ENGINEERS.

Viscount Waverley, speaking at the annual dinner of the Institution of Production Engineers last week, said he used to think that the engineers of this country laid themselves open to reproach for the excessive proliferation of professional bodies on a sectional basis. Having learnt of the activities of the Institution during its short history, and been very impressed by them, he wished to exclude it from his criticism. He congratulated the Institution on its publications and on the high standard of qualification for membership. The Institution should be supported because of the vital importance of production. Since some of this country's traditional exports, such as textiles and coal, had dwindled sadly, we had to look in other directions. It was customary, he said, to extol the achievements of the United Kingdom in research and to deplore the lack of practical application. Such criticism was not quite fair. He instanced radar, jet propulsion and new fibres: they were not only discovered in this country but were developed with conspicuous success. Viscount Waverley was responding to the toast of "The Guests," which had been proposed by Mr. Walter Puckey, President of the Institution. Mr. Puckey spoke of the growth of the Institution in the Commonwealth and of the disquieting fact that in this country only 40 per cent. of the required production engineers were being trained annually. It was a serious matter, in relation to production engineering, that more and more of the promising young men of the country were going to the universities. The dinner was held on Friday, October 9, at Guildhall, London, and the guests included (in addition to Viscount Waverley) the Lord Mayor, Sir Rupert de la Bere, and the Minister for Economic Affairs, United States Embassy, the Hon. Lincoln Gordon.

IRON AND STEEL FOUNDRIES REGULATIONS.

The Minister of Labour and National Service, Sir Walter Monckton, Q.C., has issued "The Iron and Steel Foundries Regulations, 1953," under the Factories Acts, which Regulations make provision for the safety, health and welfare of persons employed in iron and steel foundries. The regulations contain requirements regarding gangways, the suppression of dust and fumes, protective equipment, bathing facilities, clothing accommodation, and the arrangement and storage of foundry equipment and tools. With reference to gangways and pouring aisles, it is laid down that these shall have an even surface of hard material and shall be kept, so far as practicable, free from obstruction. On the subject of dust and fumes, it is stipulated that no open coal, coke or wood fires of a portable nature shall be used for heating workrooms, neither should such fires be used for heating and drying ladles and moulds unless measures are taken to prevent fumes or other impurities from entering into, or remaining in, the atmosphere of the workroom. Furthermore, all knock-out and dressing or fettling operations shall be carried out in a separate room or in a separate part of the foundry suitably partitioned off. In the matter of protective equipment, it is directed that suitable gloves, respirators and goggles be provided and maintained. With regard to bathing and ancillary facilities, it is ruled that adequate and suitable shower or other baths, dressing and changing accommodation and lockers shall be provided. On the question of arrangement and storage, it is stipulated that moulding boxes, ladles, patterns and other heavy articles shall be arranged in such a manner as to enable work to be carried out without unnecessary risk, and that suitable and conveniently accessible racks, bins or other receptacles shall be provided and used for the storage of tools and other gear. The regulations come into operation on January 1, 1954, with the exception of the requirements relating to the suppression of dust and fumes, bathing facilities and clothing accommodation, which operate from January 1, 1956. The regulations, designated S.I. 1953, No. 1464, are obtainable from H.M. Stationery Office, price 4*d*. net.

SWEDISH PNEUMATIC TOOLS AND MACHINES.

A representative of ENGINEERING recently visited Sweden as a guest of the Atlas Diesel organisation and was shown a wide range of products for mining purposes in course of manufacture, as well as their application to the winning of iron ore and to civil engineering work, such as the construction of hydro-electric stations. The present Atlas Diesel Company (to give it its English title) is the descendant of the Aktiebolaget Atlas, which was founded in 1875 to manufacture railway material of all kinds, as well as marine boilers, bridges and other ironwork. About 1890, the company also began to make pneumatic tools, including rock drills of various types, a development which led, in turn, to the familiar "Swedish method" of rock drilling. Some years later the production of Diesel engines was undertaken and this was followed by the manufacture of the compressors for which the company is now so well known. At the present time the main works of the firm are at Sickla on the outskirts of Stockholm. They cover some 50 acres and are used for the manufacture of stationary and portable compressors, rock drills and heavy pneumatic tools. A second works at Hammarby near the same city produces pneumatic rotary hand tools and also types of light equipment for mining purposes. The Avos works at Orebro is employed in the manufacture of pneumatic loading machines, while light stationary compressors and paint spraying units are made at Skara and heavy castings and forgings at the Björneborg iron works. It may be mentioned that Diesel engines are no longer manufactured, Atlas Diesel having disposed of their interests in this plant to Nydquist and Holm A.B. In the course of the visit an inspection was made of the works of Sandvikens Jernverks A.B. at Sandviken, where sponge iron is made by the Wiberg process and is subsequently used as a raw material in the manufacture of high quality steel, including Coromant tungsten carbide bits for drilling purposes. The application of these two basic products —air compressors and drills—was demonstrated during visits to the Bodas and Grangesberg ore mines and to the hydro-electric projects at Gävunda and Hummelforsen, which are now under construction. Mention also may be made of the inspections of the shipyards of A.B. Götaverken and Eriksbergs Mek Verkstads A.B. in Gothenburg, where compressed air is largely used, and to the Technical Museums in Stockholm and Falun, both of which contained many items of interest to the engineer.

MECHANICAL HANDLING DEMONSTRATION BY THE ARMY.

Exercise "King-Kong" was held on Salisbury Plain on October 6 to demonstrate the way in which the modern Army are speeding up depot and field operations by the use of mechanical-handling equipment. It was presented by the Southern Command on behalf of the War Office and observed by members of the General Staff. The actual demonstration was divided into four parts: a parade of mechanical-handling equipment, ancillaries and specimen loads; a working demonstration comprising mechanical and manual methods of handling ammunition, petrol, oil and lubricants in the maintenance area; a working display of mechanical-handling equipment; and a demonstration of the use of a cross-country type of fork-lift truck in building a Bailey bridge. The first vehicle in the parade was the new Austin Champ towing a bundled unit-load mounted on simple skids and it was followed by a Ferguson tractor pulling a three-ton sledge loaded with sections of a Bailey bridge. A number of the fork-lift trucks displayed had been fitted with tracks in place of wheels and a Taylor-Jumbo crane of 3½ tons capacity, equipped with a hydraulically-operated jib designed to allow it to pass beneath very low arches, was shown. The D.4 Caterpillar fork-lift truck which took part had earlier been operating under five feet of water, with the driver clad in a frogman's suit, as part of landing exercises held in the West of England. It was fitted with the squeeze type of lifting arms, had a capacity of 3,800 lb., a 9-ft. lift and was being driven by a member of the Women's Royal Army Corps after less than eight hours of instruction. Details of a new fork-lift truck that is being made for the Army by Conveyancer Fork Truck Company, Warrington, were displayed. It will have a road speed of 30 m.p.h. and can be used as a towing vehicle when in convoy. The cross-country speed will be 8 m.p.h. and four-wheel drive and four-wheel steering will be incorporated. The lifting height was given as 12 ft. and the load 2 tons. The final demonstration of the day was given by the Royal Engineers, who showed how the building of the extra-wide Bailey bridge could be expedited with the assistance of humper trucks of the fork-lift type and parcel-loaded equipment. One span comprising a number of bridge units was completed in 10 minutes by 28 men using the humper truck and it is understood that 40 men would have taken 45 minutes by the methods previously used.

AERONAUTICAL DOCUMENTATION.

At the second meeting of the documentation committee of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organisation, held in London recently, the subjects under discussion included the standardisation of document size and format, the issue of catalogue cards with technical reports, improving abstracting services, subject classification systems, retrieval systems for specific technical data, technical dictionaries, and research on documentation. The meeting was attended by delegates from Canada, Denmark, France, Italy, the Netherlands, the United Kingdom and the United States. The recommendations of the committee on document size and format (agreed at the first meeting in March) are generally followed by all the countries represented, apart from the United Kingdom, who are still using a size larger than that recommended (not greater than 210 mm. by 297 mm.). It is generally agreed that catalogue cards should be issued with all reports, and France, the Netherlands and the United Kingdom have made some progress in carrying this out; but difficulties arise in countries such as the United States, where reports are produced by a large number of agencies and organisations. The committee have recommended that, instead of starting an international abstracting service, existing abstract journals should be improved; at present France, the Netherlands, the United Kingdom and the United States are the only countries producing substantial aeronautical abstract bulletins, and these countries have agreed to exchange material to render the coverage of their journals more complete. In classification, a revised scheme for classifying aeronautical research

THE PRESERVATION OF OLD ENGINES.

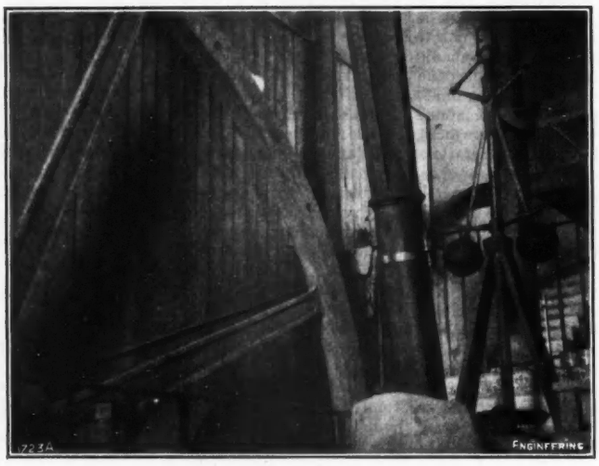


Fig. 1. Cast-Iron Flywheel.

Fig. 2. View of Beam.

and development put forward by the National Advisory Council for Aeronautics (N.A.C.A.) has been discussed, and referred back to N.A.C.A.; and the Committee have recommended that the Agard executive should contract out work on the aeronautical sections of the Universal Decimal Classifications. Details of the Dutch scheme for cataloguing aerodynamic data (referred to on page 376, *ante*) have been circulated to some 500 aeronautical organisations, and it is expected that sufficient subscribers will be forthcoming to enable the National Luchvaartlaboratorium to commence production of the catalogue cards. The United Kingdom are considering whether security-graded reports can be catalogued in a similar manner. The Société de Documentation et d'Information Technique (France) have been asked to co-ordinate the production of an aeronautical dictionary in English, French, German, Italian, Russian, and Spanish, using the British Standard Institution's Glossary of aeronautical terms as a basis. The committee agreed that more research in documentation was required, and have recommended that the Royal Aircraft Establishment should review developments in this field for further discussion at the next meeting.

THE DEVELOPMENT OF THE PORT OF SOUTHAMPTON.

It was in 1803 that the Southampton Harbour Board, which this year celebrates its 150th anniversary, came into being, in pursuance of an Act of Parliament of the reign of George III, and although to-day the port of Southampton is one of the largest and best-equipped in Britain, it is also of great antiquity and historical interest. In A.D. 50 the Romans built the fortified station of Clausentum to protect the then primitive port and river approach to the capital city of Winchester, but greater prosperity came about A.D. 1070, immediately after the Norman Conquest, which brought increased traffic between Britain and France. During the centuries which followed, the port of Southampton saw many notable events, not the least of which was the sailing of the 180-ton Mayflower on August 15, 1620, to arrive four months later at Plymouth Rock, Massachusetts. To-day, the port of Southampton is the home-port of the largest liners afloat, and commands 80 per cent. of the passenger traffic to and from the United States; there are over five miles of quays and seven dry-docks, including the George V graving dock, 1,200 ft. in length. The nearby "Esso" oil refinery at Fawley is the largest in Europe, and handles 6 million tons of petroleum products a year, most of which is exported by sea to the Continent and to other British ports. Over the years, the tonnage of imports has grown from 40,000 tons in 1803 to 12 million tons in 1952. After D-day and the invasion of the Normandy beaches had commenced, over 3½ million Service personnel and 12 million tons of stores were handled, with no less than 26 million tons of shipping entering the port during the year 1944. The spectacular rise in the traffic and goods handled during recent years is, however, to a large extent the outcome of the purchase in 1892 of the old Southampton Dock Company, by the London and South Western Railway, subsequently the Southern Railway and now part of British Railways, which has resulted in the integration of interests, as represented at the present time on the Southampton Harbour Board.

INTERNATIONAL FEDERATION OF PRESTRESSING.

The International Federation of Prestressing held its first international congress in London from Tuesday, October 6, to Friday, October 9, the technical sessions being conducted at the Institution of Civil Engineers, Great George-street, Westminster. At the official opening of the congress, the delegates were welcomed by Mr. D. H. New, chairman of the Prestressed Concrete Development Group, who acted as hosts and who made, in conjunction with the Cement and Concrete Association, all the arrangements. Mr. New announced that Mr. E. Freyssinet, in his absence, had been elected unanimously to the office of President of the Federation. During the congress, Professor G. Magnel assumed the duties of president. During the course of the congress, delegates were able to visit a number of establishments of interest. On the Wednesday they visited the prestressed-concrete hangars at London Airport, the prestressed-concrete products factory of the Concrete Development Company, Limited, Iver, and the research station of the Cement and Concrete Association at Wexham Springs. On the Thursday, the delegates were able to see a second factory, that of the Costain Concrete Company, Limited, Childerditch, and two prestressed-concrete structures, a gantry and covered culvert both in the London area. On the fourth and final day a tour was made of the Southampton and New Forest area, where delegates saw the new Norton Bridge, a five-span road bridge, under construction at Southampton, the bus-garage of the Bournemouth Municipal Corporation, a demonstration of the Gifford-Udall prestressing jack at the works of J. J. Udall's Building Company, Limited, Southampton, and numerous other prestressed-concrete road and foot bridges in the New Forest area. A Government Reception was held for the overseas delegates and their ladies on the evening of Tuesday, October 6, and the Prestressed Concrete Development Group gave a dinner in honour of their guests during Thursday evening. A summary of the reports submitted to the congress is commenced on page 490 of this issue.

LETTER TO THE EDITOR.

THE PRESERVATION OF OLD ENGINES.

To the Editor of Engineering.

Sir,—Following Mr. L. E. Harris's letter on page 371 of your issue of September 18, I enclose some photographs which I have recently taken of the Butterley beam engine installed to drain Stretham Mere in 1831, and which I thought your readers would be interested to see. Fig. 1 shows part of the great cast-iron flywheel, the eccentric and governor and the lower part of the pitman or connecting rod between the main shaft and the beam. Fig. 2 shows the beam. So far as I am aware, this engine was used in the great flood of 1947, when it ran continuously for several days.

Yours faithfully,

P. H. Laws.

The Cottage,
Wisbech St. Mary,
Wisbech, Cambridgeshire.
October 6, 1953.

OBITUARY.

MR. L. RIPLEY, O.B.E.

Shipbuilders and metallurgists in many parts of the United Kingdom and Europe will learn with regret of the sudden death of Mr. Louis Ripley, which occurred at Danby, North Yorkshire, on October 5. Mr. Ripley, who was 73 years of age, was for over 25 years special surveyor for steel to Lloyd's Register of Shipping. He commenced his early training and career with Messrs. William Jessop and Sons, Limited, Sheffield, and remained with them for 20 years. In 1919 he severed his connection with Messrs. Jessop and joined the staff of Lloyd's Register as surveyor for steel. Mr. Ripley was stationed in the Glasgow district from 1919 until 1928, during which he was elected a member of the West of Scotland Iron and Steel Institute and became a vice-president. In November, 1928, he was transferred to Middlesbrough and retired under the age limit in 1945. His duties took him to practically every European country and he became well known to many steel metallurgists as well as to shipbuilders and engineers. For his services to his country during the late war, he was made an Officer of the Order of the British Empire. After his retirement from Lloyd's Register, Mr. Ripley was elected a director of Messrs. Blackett, Hutton and Company, Limited, Cleveland Steel Foundry, Guisborough, Yorkshire, and it was only recently that he relinquished this position. Mr. Ripley was elected a member of the Iron and Steel Institute in 1917.

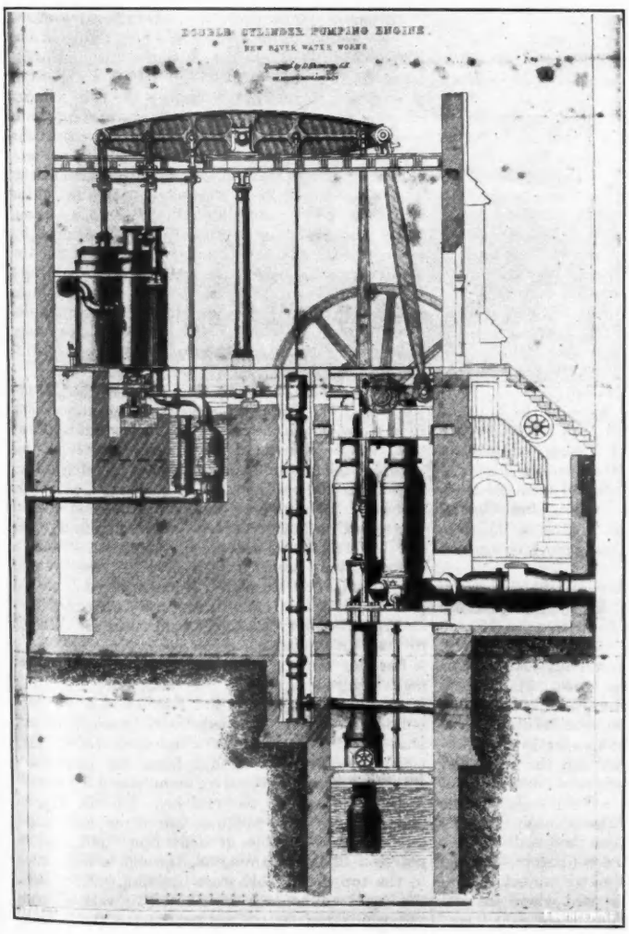
DISMANTLING OLD BEAM ENGINES OF THE METROPOLITAN WATER BOARD.

The disappearance of historic beam engines was lamented in a letter from Mr. L. E. Harris which we published on page 371 of our issue of September 18. Another correspondent's letter on the subject is published on page 500 of this issue. In the same week comes an account of the dismantling of some old beam engines by the Dismantling and Demolition Department of George Cohen, Sons and Company, Limited. Six of these pumping engines, which were inherited by the Metropolitan Water Board, have served London for a century or more. Their uneconomical fuel consumption was sufficient reason for dismantling them, but as Messrs. George Cohen remark, "the skill of the men who designed and built them remains as impressive as the great engines they created."

The six engines, at the Board's Stoke Newington pumping station, together with the pump-house, were constructed for the New River Company in 1856, the work being carried out under the direction of the company's engineer, William Chadwell Mylne. They were designed to lift water from the New River filter beds to the Dartmouth Park Hill reservoir, and, later, to the Crouch Hill reservoir, a height of 133 ft. Mylne was a man of considerable personality and his ideas on pump-house architecture were unorthodox, to say the least. It is said that he based his general conception of the Stoke Newington building on the Keep of Edinburgh Castle but that, finding the true proportions at odds with the building's function, he borrowed those of Stirling Castle. Closer inspection, however, reveals that the building's ornamentation is far from superfluous. The three buttresses that adorn the west wall are, in fact, hollow and house parts of the flywheels within. A stumpy tower in the north corner contains the spiral staircase that gives access to the beam loft; and a taller tower diagonally opposite conceals the stand-pipe.

The engines consisted originally of a coupled pair of simple engines designed and built by Boulton and Watt, and two identical pairs of compound engines designed by David Thomson and built by J. Simpson and Company. The former, the largest of the three and named "Lion" and "Lioness," have beams measuring 28 ft. between bearing centres and weighing 22 tons, each being cast in two cheeks. Their common flywheel was Lancashire-built in ten segments and each spoke is individually keyed to the rim and hub. Its diameter is 25 ft. and it weighs 35 tons. The beam of the Simpson engines (a drawing of which, taken from John Bourne's *A Treatise on the Steam Engine*, is reproduced below) although also 28 ft. long, weigh only 11 tons, while the two 18-ft. diameter flywheels weigh 25 tons each. It would appear that the choice of two sets of compounds and one of simples was made deliberately with a view to comparing the relative merits of the rival systems. Although no proper tests were carried out, John Bourne claimed that the venture had established that "the use of two cylinders involves a needless complication, as has always been maintained by Boulton and Watt." That was in 1872. Nine years later opinions seem to have changed, for in 1881 "Lion" and "Lioness" were converted to compounding by John Simpson and Company.

The new high-pressure and low-pressure cylinders had bores of 48 in. and 77 in., respectively, and a stroke of 8 ft. They increased the engines' power to 500 h.p. and enabled the four pumps to which they were connected to deliver approximately 14 million gallons per day at 14 strokes per minute. The valve gear was actuated by a bevel pinion mounted on the flywheel hub and fitted with teeth of hornbeam, this engaging with a cast-iron pinion. After 98 years working not one of these teeth has had to be replaced through wear. The smaller engines also underwent modification, their original piston valves being replaced in 1880 by drop valves. Each pair developed 360 h.p. and pumped 6 million gallons per day at 15 to 16 strokes per minute. Their thermal efficiency was about 8 per cent. The modifications complete, the engines settled down to over 70 years of almost uninterrupted work. An occasional break for one or two hours was all they could be given and at times they ran for months without a pause. Yet only once was there a major breakdown. This occurred in 1908, when a pump rod on the Lion snapped. The job of repairing it was given to the Swedish Arc Welding Company and although arc welding was then in its infancy, the join stood up to another forty-odd years of service. The Board have asked Messrs. George Cohen to return to them the repaired portion of the rod to enable them to break it down and examine this remarkable weld.



MODERN DEVELOPMENTS IN STRUCTURAL ENGINEERING.

In his presidential address to the Institution of Structural Engineers on Thursday, October 1, Lt.-Colonel R. F. Galbraith, M.C., B.Sc. (Eng.), took the opportunity to review the recent trends in all fields of structural engineering, illustrating his remarks with numerous slides. Beginning with foundation work, Colonel Galbraith remarked that the developments in site investigation and in the theory and practice of soil mechanics had enabled structural engineers to depart from the rather empirical rules that merely defined safe bearing pressures for various types of soils and to predict with much greater certainty the probable sub-soil conditions and to design accordingly. A comparison drawn between the approach to foundation problems only 15 years ago and that now adopted enabled Colonel Galbraith to demonstrate the increase in knowledge that has been built up in that period and the extent to which that knowledge has been distributed. The value of geophysical methods to determine the depth of the bedrock, so saving the cost of unnecessary drilling, was also referred to; the results obtained by seismic methods were said to be accurate to within 10 per cent.

Turning to earth-moving machinery, Colonel Galbraith mentioned that the earliest record of a mechanical excavator was that of the Otis steam shovel, which was designed and built in 1837 in Philadelphia. The great changes that have taken place since that date, particularly during the last two decades, were illustrated. From the machinery used to shift the spoil, the President turned to the recently adopted methods of ground-water lowering and he referred to the various forms and combinations of filters and pumps that could be installed for this work. He then concluded his remarks on foundations by referring briefly to the geo-technical processes which have provided solutions in so many difficult problems; particular mention was made of freezing, and of the injection processes which include cement grouting and other chemical consolidation methods.

Before dealing with the alternative materials now being exploited in constructional work, Colonel Galbraith drew attention to the theories that had been introduced recently for examining the strength of proposed structures. It was unfortunate, commented the President, that there had not been a greater acceptance of the recommendations made in the final report, published in 1937, of the Steel Structures Research Committee. The adoption of the rational methods of design proposed in that report would have led, Colonel Galbraith claimed, to considerable economy in the use of steel. However, the work that had been done since the war by Professor J. F. Baker and his assistants at the University of Cambridge in developing the so-called "plastic theories" had led to a marked saving in materials. As an illustration, the case was quoted of a storage shed of 60-ft. width where the application of the plastic theory to the design had enabled the steel used to be reduced from 4·54 lb. per square foot of covered area when the design was based on conventional elastic theories to 3·10 lb. per square foot.

The development of plastic theories for concrete members was also mentioned, particularly the work being undertaken at the City and Guilds Institute under the guidance of Professor A. L. L. Baker. To off-set the difficult and complex mathematics that these and other theories were requiring, the President called attention to the various forms of model analysis that were in current use.

Colonel Galbraith then dealt briefly with each of the principal materials that are now being used. Speaking of high-tensile steel, of the type specified in B.S. 548, he pointed out that a number of buildings with heavy floor loadings had now been constructed with this material, the additional unit cost of 10 per cent. being more than offset by the 30 per cent. saving in material that was achieved. Referring to the more slender members that could be employed with such steel, he remarked that increased headroom usually resulted from

its use. For bridge work, however, the President reminded members that the higher stresses that were allowed meant that, since the modulus was not sensibly different from that of the more familiar mild steel, higher deflections would be encountered than those to which they were accustomed. Appropriate modifications would have to be made to established practice.

As an example of the rapid progress that has been made in recent years, Colonel Galbraith mentioned improvements in welding, especially in the design and manufacture of the electrodes. The outstanding use to which welding had been put was the production of the Bailey bridge units, which had been used to such great advantage during the recent war. The Freeman Bridge over the River Rhine and the Festival of Britain Bridge over the Thames were just two examples of the uses to which Bailey bridges had been put in both war and peace.

In referring to reinforced concrete, the President drew attention to the wider use of higher working stresses in the steel, of up to 20,000 lb. per square inch, but, apart from grounds of economy, he could see little justification for the increase. In conjunction with these higher stresses, the practice of using deformed bars was being extended so as to take advantage of the increased bond that resulted with their use. But the use of such high stresses resulted in larger strains, and a consequent increase in the total width of the cracking incurred. This difficulty could be eased, he suggested, by the use of secondary reinforcement. Whether this would offset the initial saving in steel was a matter that experience alone would show. In any case, he thought that the cover concrete should not be reduced below 2 in.

Of the concrete itself, Colonel Galbraith drew attention to the great improvements that had been achieved recently in the strength of the material, improvements which he attributed to the careful design of mixes now used and also to the improved patterns of mixing plant which have come into use in recent years. For handling the concrete, the President indicated his liking for the small power-driven barrows and the newer types of mobile crane where conditions were appropriate. Under alternative conditions, pumping concrete had much to offer and figures were quoted for distances over which the concrete could be pumped and the capacities of the pumps that are now available. Concrete which could be pumped, he said, was of necessity a good concrete. Regarding modern developments of prestressed concrete, precast concrete and shell roofs, Colonel Galbraith limited his remarks to brief reviews of the history of these innovations, leaving it to the members to judge the applications of each from the slides that were shown.

A method of construction that has received a great deal of attention recently was that of tubular structures, the use of which was so amply illustrated by the erection of all the temporary stands along the Coronation route, and Colonel Galbraith drew attention to the recently published code of practice on this subject (C.P.113 : 201, 1953). But the most dramatic use of tubular construction, he suggested, was the fabrication of the jib for the 1,600-ton walking drag-line that had recently been installed on the site at Corby in Northamptonshire. Details of the steels used, specially developed for that particular problem, were given in the address. As a final commentary on the materials now in use, Colonel Galbraith mentioned the position of light alloys as a structural material. The advantages were, he said, apart from lightness, the small degree of surface decoration that was required and the low maintenance that was to be expected.

Colonel Galbraith concluded his presidential address with some personal reflections on the immediate future. Two materials for which he suggested there might be a future as structural materials were glass and nylon, the latter as a non-corrodible reinforcement. But of greatest value, he considered, was an extension of the education of the small contractor, his agent and his workpeople in the use of modern techniques. The training courses held by the Cement and Concrete Association for foremen and others were doing most excellent work and should be encouraged by all the means that were available.

ICE-CREAM MANUFACTURING PLANT.

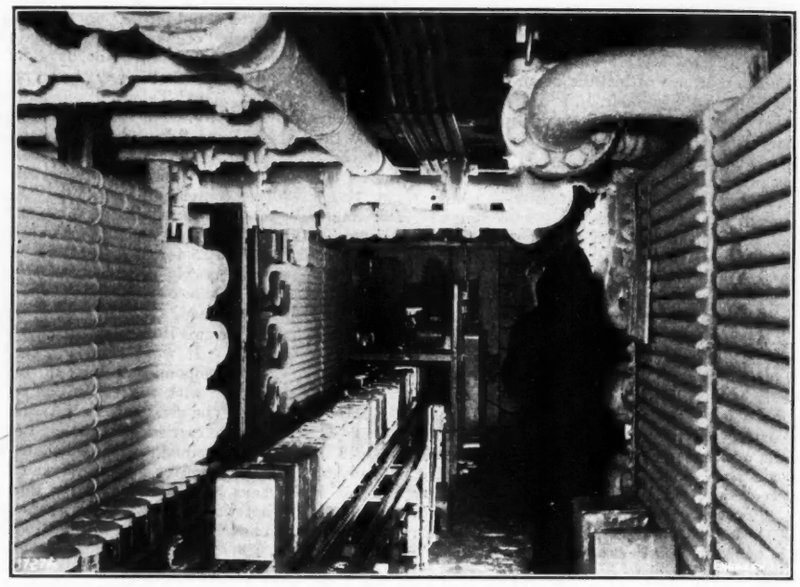


Fig. 1. Part of Cold Store.

ICE-CREAM COLD STORE AND MANUFACTURING PLANT.

At the London ice-cream factory of Messrs. T. Wall and Sons, Limited, The Friary, Acton, London, W.3, a new cold store with a capacity of about 200,000 cub. ft. capable of holding nearly 1,000 tons of ice-cream, has recently been put into operation. It comprises a three-storey steel-framed structure enclosed within thermally-insulated brick walls which are completely separate from the cold-store structure itself. The latter is built on stilts to prevent the ground below the store from freezing and causing "frost heave"—i.e., a tendency for the frozen earth to lift the building and damage the foundations. Entry to the store is through air locks and, to prevent ice from forming round the doors and jamming them, electrically-heated metal plates are provided around the lintel of each door. After the contractors, Messrs. William Cubitt and Company, 1, Queen Anne's Gate, London, S.W.1, had completed the building, the temperature was brought down slowly to — 15 deg. F., over a period of four weeks, in order to avoid damage to the structure from too rapid contraction.

The first, second and third floors of the building serve for distribution to the whole of England south of the Trent. On the ground floor, in addition to office accommodation, there are two smaller refrigerated rooms, completely separated from the main cold store, which serve the Acton and Central London areas. Below these rooms a thermostatically controlled electric mat provides against the risk of "frost heave."

So far as possible, handling of the ice-cream within the store is mechanised by the extensive use of belt and chain conveyors, supplied by Messrs. W. and C. Pantin, Limited, Centre-road, Epping. About 20 men only are required for loading and unloading the goods into the store. Six ingoing and seven outgoing slat conveyors, two serving each floor, are controlled from a cabin outside the store, a microphone and loud-speaker system providing intercommunication between the controller and the loading staff. On each floor, internal conveyors of the chain-link type are controlled by the loading staff on that floor. The seventh outgoing conveyor is reversible, and can be used to take returned ice-cream back to the cold store. All the outgoing conveyors converge in an airlock before they emerge into the dispatch yard where the ice-cream vans are loaded; many of these vans incorporate built-in roller conveyors to expedite loading.

Refrigeration of Cold Store.

Fig. 1 shows part of the interior of the cold store, which contains a vast number of ammonia cooling coils, the equivalent of about 1 ft. of 1½-in. outside-diameter tubing being provided to every cubic foot of store; the average room temperature is about — 20 deg. F. The whole of the refrigerating plant, in the store and in the factory, has been designed and supplied by the Lightfoot Refrigeration Company, Limited, Abbeydale-road, Wembley. For a plant of this nature, in which the load on the refrigerating system fluctuates widely over the year in response to public demand, the essential design considerations are reliability, simplicity, thermal efficiency and flexibility of operation. The use of an air circulation system for the cold store was considered, but for two reasons it was not adopted: firstly, the volume of air to provide the degree of cooling required by ice-cream in any condition, in any part of the store, would be considerable, and much space would be required for ducts and coolers. The available space was, in fact, very restricted. Secondly, the working conditions under an air-circulation system at — 20 deg. F. would be extremely severe. A still-air and coils system was therefore chosen.

The selection of ammonia as the refrigerant followed from the plant already in existance, but in any case it was the most suitable for this application which demanded automatic operation and required the use of large quantities of refrigerant; carbon-dioxide refrigeration is relatively inefficient especially at extreme temperatures and when maximum output is needed; the refrigerant does not lend itself to automatic operation. With a Freon system, apart from the cost of the system, difficulties arise through its susceptibility to the presence of water, even in the minutest quantities, and its miscibility with oil; and leaks are difficult to trace and to prevent.

For the two top floors a pump system circulating anhydrous ammonia was adopted. The compressors and condensers are located in a separate building. Within the new cold store building, above first-floor level, is a receiver vessel, into which anhydrous ammonia from the condensers enters through a float valve, maintaining a constant liquid level within the receiver. On the ground floor of the store building are three centrifugal pumps, each capable of delivering 5,000 gallons per hour of liquid ammonia, through a 5-in. main to the top of the cold-store building. From here, the liquid ammonia is distributed to vertical grids and ceiling grids on the top two floors; the arrangement of the coils on these two floors is identical,

ICE-CREAM MANUFACTURING PLANT.

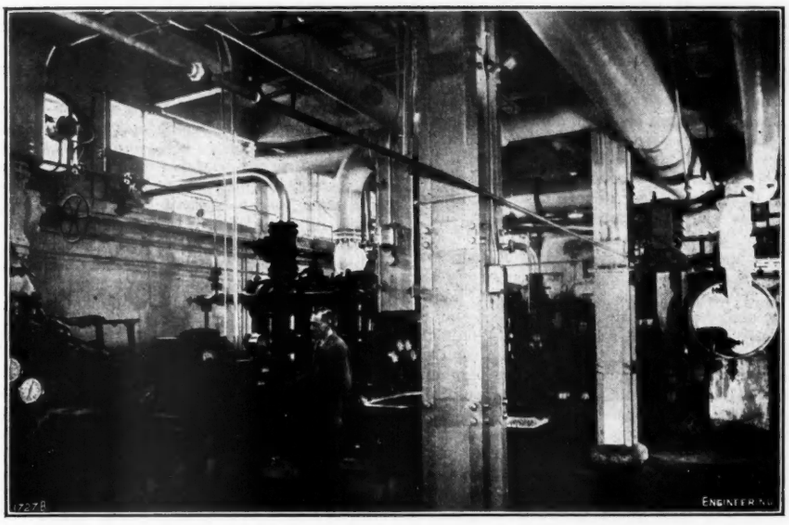


Fig. 2. Compressor Room.

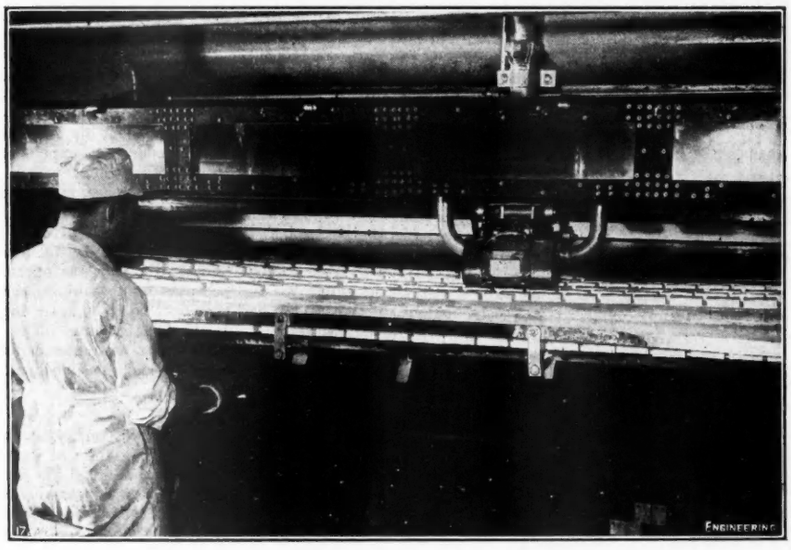


Fig. 3. Briquettes being Extruded and Frozen.

and they have therefore been coupled together vertically to form a continuous system. Liquid ammonia is fed into the top of the coils; depending on the load fed into the cold store, some of the ammonia evaporates and the gas is drawn from the coils at various points along its length, thus ensuring that the evaporating temperature, which depends upon the gas pressure and thus on the gas velocity through the coil, is reasonably constant throughout the coil. Liquid draining from the coils is ducted back to the receiver. The ammonia gas is led to a separator at the top of the store building; from here, any entrained liquid drains back into the receiver, and the gas is led to the compressors. By this means, any possibility of liquid ammonia being carried over from the receiver to the compressors, in the event of a pump failure, and the coils filling, is avoided. In order to protect the pumps, in the initial stages of operation, from foreign matter which may have collected in the coils during erection, filters are fitted on the suction side of the pumps.

A different feed system is used for the coils on the first floor, the arrangement of these coils varying from those on the other two floors; these coils are flooded, from the bottom, with liquid ammonia from the receiver almost to their full height. The gas separator for the top floors also serves the first-floor system.

Compressor Plant.

At present the cold-store refrigerator system is supplied by two high-pressure four-cylinder single-acting compressors, driven by 150-h.p. motors, but ultimately it will be supplied by a two-stage plant, such as already serves the main factory. Part of the existing main compressor plant is illustrated in Fig. 2. It comprises ten three-cylinder single-acting booster compressors with a 14-in. bore and an 8½-in. stroke, driven at 300 r.p.m. by 80-h.p. motors; and six high-pressure compressors—five single-cylinder double-acting horizontal machines, with a 17½-in. bore and 34-in. stroke, running at 80 r.p.m. and driven by 300-h.p. motors; and one four-cylinder single-acting vertical machine with an 11½-in. bore and 11-in. stroke, running at 300 r.p.m. and driven by a 330-h.p. motor. The suction pressure at the low-pressure compressors corresponds to a temperature of — 45 deg. F., and the low-pressure delivery is at about 25 lb. per square inch gauge. The high-pressure delivery, in the height of summer, rises to about 180 lb. per square inch gauge.

After compression in the booster compressor, the gas is cooled to 100 deg. F. by water-cooled heat exchangers, comprising gilled water tubes over which the gas is passed. It is of great importance for efficient freezer operation that no oil shall be entrained in the refrigerant, and therefore after passing through the heat exchanger the gas is cleaned and further cooled in a "washer de-superheater." In the latter, the gas is forced to flow round closely-spaced plates submerged in anhydrous ammonia; in so doing, any oil entrained by the refrigerant is removed by gravity. The gas rises through the cylindrical body of the de-superheater which is made sufficiently high to prevent any carry-over of liquid, and thence to the high-pressure compressor, from which it is again discharged to a washer de-superheater, after which it passes to water-cooled condensers on the roof of the building. These condensers, of the atmospheric coil type, were selected for their reliability and ease of maintenance.

Production of Ice-Cream.

It may be of interest to describe briefly the processes by which the ice-cream is made. Raw materials are unloaded from road transport vehicles in the loading bank; liquid sugar-syrup is piped directly from tank wagons to the factory storage vats. The raw materials, principally sugar, milk powder and fats, are weighed and measured in the mixing room, and are blended together with water in 300-gallon stainless-steel tanks. The blended mixture is led through stainless-steel pipes into 500-gallon vessels in the Pasteurising room, where they are Pasteurised at 155 deg. F. for 30 minutes, to ensure that any harmful bacteria are destroyed. The Pasteurising vessels, of stainless steel, are jacketed and are heated by hot water sprays in order to avoid burning the mixture.

The liquid mixture now passes through a plate-type filter, comprising eight fine gauze leaves, which removes all solids, into 1,000-gallon homogenisers. In these, the mixture is forced under a pressure of 2,000 lb. per square inch through a fine aperture, thus emulsifying the fat and distributing it throughout the mixture to ensure a smooth texture. The hot mixture is then passed through a Mojonnier cooler capable of handling 1,000 gallons per hour; the top halves of the cooling leaves, of which there are eight, are water-cooled, and the lower parts are cooled by liquid ammonia. The cooled mixture then passes to mix storage tanks; in one of the three production plants there are five such tanks, glass-lined or of stainless steel, with a total capacity of 13,300 gallons.

The liquid mixture is frozen to a plastic state in continuous freezers, each of which embodies two pumps. Mixture from the storage tanks is fed through a hopper to the first-stage pump, which delivers it to the second-stage pump, in the suction side of which is an adjustable air-intake valve, which admits a controlled amount of air to give the required texture to the product. The pump, which operates at high speed, forces the aerated mixture into the barrel of the freezer, which is surrounded by liquid ammonia, where it is whipped by two scrapers mounted on a "mutator" shaft rotating at about 600 r.p.m.

Ice-cream that is to be sold in gallon-bulk containers or packaged as "family bricks" or tubs, is extruded directly into the container. The filled containers are then passed through blast-hardening tunnels, remaining in the tunnel for 50 minutes, where they are thoroughly hardened by a blast of air at — 20 deg. F. The packages are then delivered by conveyor to the cold store for distribution.

Briquettes or "bumper bars" are processed in the Stonestreet tunnel, a machine designed by the company, capable of producing 180 briquettes per minute. The machine illustrated in Fig. 3 is one of 12 such machines in the Acton factory. Plastic ice-cream from the freezer is extruded through a moving head which traverses the width of a continuous belt, which is advanced in steps each time the head reaches the end of a traverse. As the cream is extruded, it is sliced by a rotating wire cutter to form briquettes which are delivered

on to the belt in rows of 22 and are carried by the belt into a blast-hardening tunnel maintained at a temperature of — 25 deg. F. As the briquettes freeze, they stick to the belt so that when they reach the end of the tunnel they remain adhering to the underside of the belts and are carried by it to the front of the tunnel. Here a stripper bar transfers them to a rubberised conveyor belt which carries them to Rose wrapping machines. After wrapping, the briquettes are delivered to plastic containers on the bundling machine, where they are wrapped, in bundles of six, in parchment or greaseproof paper, and are then packed into metal cans containing 96 briquettes for transfer to the cold store.

Slightly smaller briquettes, also produced in the Stonestreet tunnel, are used for "chocbars." These briquettes are conveyed to the "enrober," where they are passed, on a wire belt, under a "waterfall" and through a pool of molten chocolate, produced in a 700-lb. capacity kettle. The covered bars are then transferred by a brine-cooled belt to Rose wrapping machines, with a capacity of 100 bars per minute. They are then packed in boxes of 24, four such boxes being packed in a metal can for storage and distribution. At the end of the day, the whole of the ice-cream plant is thoroughly cleaned, washed with detergents and sterilised.

Solid Carbon-Dioxide Plant.

Solid carbon dioxide for use in refrigerated vans, cabinets and gateau boxes for keeping the ice-cream fresh, is produced on the site in the "snow" plant. The carbon dioxide is produced by burning special foundry coke in boilers, the steam from these boilers being used for driving machinery and for heating purposes. The flue gasses are washed and are then passed successively through five 90-ft. absorption towers, where they are washed with a strong solution of potassium carbonate which absorbs the gaseous carbon dioxide when cool. On boiling the solution, the carbon dioxide is released. It is dried and compressed in stages to a pressure of 1,200 lb. per square inch, at which pressure, with subsequent cooling, it liquifies. The liquid carbon dioxide, injected into insulated snow towers, is transformed into powdery snow, and is compressed into blocks by hydraulic presses under the snow towers. Each block, weighing about 60 lb., is cut into smaller blocks on a band saw. In this state, the temperature of the "snow" is — 109 deg. F.

PETERBOROUGH TECHNICAL COLLEGE.

Work on the erection of the first instalment of the new building to house Peterborough Technical College commenced on May 9, 1949, but subsequent progress was slow owing to difficulties in the supply of labour. Finally, however, the premises were handed over for occupation on September 15, 1952, and their official opening was conducted by Lord Percy of Newcastle on October 1, last. The present buildings represent about one-third of the entire College for which plans have been drawn up, and consist of the departments of building and engineering and the bakery school. Included in the sections needed to complete the project as originally planned are the departments of science, commerce and art, an assembly hall and a library. The full-time work of the College is at present confined to general educational, pre-apprenticeship, and commercial courses mainly for pupils who have just left secondary modern schools. Part-time courses, however, are now provided, leading to the intermediate and final B.Sc. examinations of the University of London, and to Ordinary and Higher National Certificates in electrical, mechanical and production engineering. Other part-time courses prepare students for Ordinary National Certificates and City and Guilds of London Institute Certificates for machinists and fitters, motor-vehicle mechanics, founders, and welders, and for building, sheet metal work, electrical installation, plumbing, brickwork, carpentry, gas fitting, architectural design and other crafts. The building of further instalments of the College has been deferred owing to financial and other considerations, but, meanwhile, courses will continue to be held in temporary premises erected seven years ago and in several schools.

LABOUR NOTES.

Trade unions played an important part in the life of the nation, Sir Winston Churchill reminded his audience, when addressing a large meeting of members of the Conservative Party at the close of the Party's annual conference at Margate last Saturday. He said it was not sought to bring them into the Conservative Party, but the Party did ask, as he himself had been doing for some time, that all Conservative wage-earners should join trade unions and take an effective part in their daily work. He had often said that the trade unions should keep clear of both parties and devote themselves solely to industrial matters.

Of economic matters, the Prime Minister said that he hoped that there would soon be a return to the free and flexible working of the laws of supply and demand. He wished to see the restoration of buying and selling between individual importers and exporters in different countries, instead of a continuation of the clumsy bargaining of one State against another, biased by politics as such agreements must necessarily be. Great advances had been made recently in resuming this method of "active, nimble, multiple private trading," and it should be permitted to flourish as long as the laws against the abuses of monopolies were vigilantly enforced. It was surely better that consumers should buy their food and raw materials from private traders who had to make a profit by good management and shrewd business, or go into bankruptcy and out of business.

With reference to nationalisation, the Prime Minister said that the lessons and experiences of the last few years were having their effect on all shades of opinion in this country. Nothing was clearer than that many large and important sections of the public, who had hitherto believed implicitly in collectivism, were altering their views. The fallacy of the nationalisation of all the means of production, distribution and exchange, which had been regarded for long as an El Dorado, had become apparent to millions of people. There were now grave doubts about the theory of State ownership and there were even more disagreements about its practice. Trade unions and co-operative societies were organisations in daily contact with reality, and there was anxiety among them lest the practical interests of the large masses for whom they were responsible should be endangered.

As was inevitable, a number of questions of labour and industrial interest were among the wide range of political and economic subjects discussed at the three-day annual conference of Conservative and Unionist Associations which opened on October 8. Emphasis was laid on the importance of raising the general quality of education, but it was pointed out that it would be fatal to raise the average quality at the expense of the best, and to the detriment of the prospects of the brightest children, whose importance to the nation was so great. Reference was made to the crippling effects of heavy taxation and there were pleas that there should be further economies in State expenditure. Industry, it was affirmed, should be allowed to retain some of the millions of pounds now being taken by the Treasury, so as to enable it to compete more effectively in what was no longer a sellers' market.

In a statement on the economic outlook, Mr. R. A. Butler, Chancellor of the Exchequer, said that, during the last year, the nation's resources had been increased by 800 million dollars, and there was likely to be a steady improvement in the future. In fact, the current overseas payments position had worked out even better than he had expected, as it was a time of year when purchases of tobacco, grain and other commodities had to be made in the dollar area. It was imperative, however, that the rate of improvement should be increased wherever possible by all the ability, resource and inventiveness which employers, workpeople and the Government could bring to bear on the industrial problems with which they might be faced.

As to the future, it was essential to maintain the stability of the Budget, but the Government was fully aware of the absolute need of keeping down living costs, in the interests of industry and of workpeople generally. More capital investments in industry were needed and, for the sake of the balance of payments, a high level of agricultural production must be maintained. On the second day of the conference, various speakers stated that there was much concern among farmers regarding the Government's apparent delay in arranging a comprehensive policy of assured markets and guaranteed prices to take the place of controls. Later, Sir Thomas Dugdale, the Minister of Agriculture, said he was confident that any anxiety which existed among the farming community would be dissolved when the Government's policy respecting agriculture was generally understood. A resolution asking the Government to lower the age at which post-war credits are repaid was carried by ballot on the last day of the conference.

The wage claim of the Confederation of Shipbuilding and Engineering Unions for an increase of 3*s.* in the pound on the consolidated time rates of all adult male employees in the engineering industry was rejected outright by the Engineering and Allied Employers' National Federation on October 7. In all, some 2,500,000 employees are affected by the claim, which, it has been estimated, would add about 125 million pounds to the annual wage bill for the industry, if the demands were conceded in full. The rejection of the claim was made known at a meeting in London of representatives of the two sides. On the following day, the executive council of the Confederation met in York to consider the employers' decision and decided unanimously to ask the Federation for a further meeting at an early date.

At the joint meeting in London, Sir Percy Mills, Bt., the President of the Federation, expressed the dismay felt by his members when, within five months of the previous wage increase, in November, 1952, they heard that the unions were to present another demand for an all-round advance. He said that the increase last year, of 7*s.* 4*d.* a week, had been granted reluctantly, and was offered by the employers and accepted by the unions, because at that time it had been deemed to be in the highest national interests to take that course. The concession was far from popular with member firms and, since that time, order books had declined still further.

No doubt the inflationary conditions which continued for several years after the last war were the reason why the unions had adopted the practice of submitting claims for substantial wage increases each year. The present claim had been submitted at a time when prices generally were no longer rising and when it was obvious that the time had come to try to achieve stability. The payment-by-results schemes in the industry ensured that increased productivity meant higher earnings for employees. The Federation hoped that the reasoned reply which had been given to the unions would receive their full and searching consideration.

Earlier, Mr. B. Macarty, the director of the Federation, had stated that it was not true, as the unions had claimed, that earnings in the engineering industry had not kept pace with the rise in the cost of living, and he quoted figures in support of this contention. Higher output in the industry had been largely due to improved techniques and to new and more efficient machines. For some time, output had been in excess of incoming orders. During the year ended May, 1953, there had been a reduction of 25 per cent. in the volume of orders, and this followed a decline of 8 per cent. during the previous year. Export orders accounted for the greater part of this decline. The time had passed when prices once tendered could be altered to meet increases in wages and in the cost of raw materials. Wage increases could not be met out of profits. These showed a downward trend and a large proportion of them had to be ploughed back to keep the industry efficient.

THE DESIGN OF CREEP-RESISTING STEELS.*

By E. W. COLBECK, M.A., F.I.M., J. R. RAIT, Ph.D., DSc., A.R.T.C., F.I.M., and J. O. WARD, A.Met., A.I.M.

IT is probable that the phenomenon of creep in metals has been observed throughout the centuries during which mankind has used the soft metals lead, tin and zinc. However the recognition of this time-dependent deformation does not appear to have been recorded until the Twentieth Century. In 1905, Phillips[1]† published the first recorded creep data and he noted an empirical logarithmic relationship between the duration of load application and the total deformation observed. The first scientific study of the creep deformation of a number of pure metals was reported by Andrade[2] [3] who derived a theoretical equation which could be applied to all the metals studied. The importance of this work was not realised until Dickenson[4] published the first long-term creep tests on steels in 1922. During the next decade much attention was devoted to methods of testing, the work of Tapsell,[5] McVetty,[6] Kantner and Spring,[7] Barr and Bardgett,[8] and Hatfield[9] being particularly noteworthy. Tapsell's book, *Creep of Metals*,[5] contains an admirable summary of the knowledge available up till 1930.

From 1930 onwards, the study of creep has proceeded at an ever increasing rate, and the demands of war, together with the advent of the gas turbine, necessitated the development of steels and other alloys with remarkable high-temperature properties. This rapid technological expansion has outstripped the development of creep theory with the result that the mechanisms underlying creep deformation are as yet imperfectly understood. In Fig. 1, a typical creep curve is shown and the three characteristic stages are readily observed, i.e., primary creep characterised by a diminishing creep rate, the second stage of approximately steady creep rate, and tertiary creep where the rate of extension progressively increases until fracture occurs. The test piece used was prepared from a 1-in. diameter rolled bar with the following analysis: C, 0·23 to 0·22; Si, 0·43; S, 0·006; P, 0·014; Mn, 0·03; Cr, 3·08; Ni, 0·24; Mo, 0·67; V, 1·0; and W, 0·52. Heat treatment: 1,150 deg. C. (half hour) air; 1,060 deg. C. (¾ hour) oil; and 700 deg. C. (one hour) air. Elastic strain, 0·107 per cent., plastic strain, nil. Brinell hardness before test 288; after test 256. Theoretical work on pure metals has shown that the primary and secondary stages of creep consist essentially of a two-component flow much as originally postulated in Andrade's classic equation:—

$$l = l_0 (l + \beta t^{\frac{1}{3}}) e^{Kt}$$

where l = length after duration of test, l_0 = length immediately after loading, t = duration of test, e = base of natural logarithms, β = a constant, and K = a constant. Many other complex equations have been formulated all of which describe in essence a two-component flow with various correction factors added in order to obtain a better correlation between theoretical and practical creep curves; this theoretical approach is admirably summarised by Sully[10] and Rotherham.[11] The onset, and characteristics of the tertiary creep has not so far been satisfactorily explained, but evidence is beginning to show that this is often associated with metallurgical changes, such as precipitation of carbides, over-ageing, resolution of carbides, phase changes or recrystallisation. It is not proposed to discuss the theories of creep as such but to show how the development of materials has been carried out.

Fig. 1. CREEP TEST ON HGT 3 STEEL.

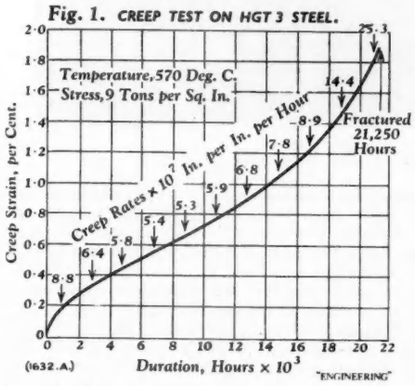
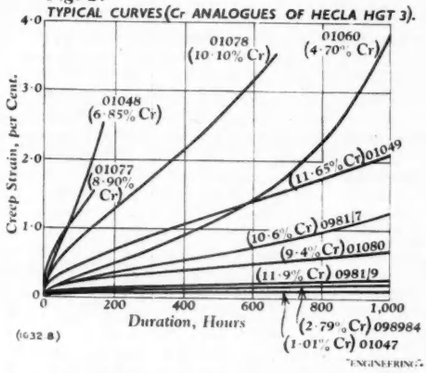

Temperature, 570 Deg. C.
Stress, 9 Tons per Sq. In.
Creep Rates × 10⁷ In. per In. per Hour
Fractured 21,250 Hours
Creep Strain, per Cent.
Duration, Hours × 10³
(1632.A.)
"ENGINEERING"

Fig. 2. TYPICAL CURVES (Cr ANALOGUES OF HECLA HGT 3).



This time-dependent type of deformation occurs in many engineering components, such as turbine blading, rotors, cases, superheater tubes, furnace components, etc. In most practical applications, factors other than creep have to be considered, and compromises must often be sought between creep resistance and such factors as impact strength, corrosion and oxidation resistance, tensile strength and thermal-shock resistance. In all cases the method of fabrication has to be considered and it should be pointed out, in this respect, that creep resistance usually implies metallurgical characteristics which cause difficulty in forging, heat treatment and machining.

Property Requirements.—The following properties are commonly required in high-temperature materials; sometimes only one is required, often two or more may be critical:—

(*a*) *Mechanical Properties:* tensile strength at room temperature and at high temperatures, creep resistance, fatigue resistance, resistance to impact loading particularly after prolonged soaking at temperature.

(*b*) *Chemical Properties:* oxidation and corrosion resistance.

(*c*) *Physical Properties:* expansion coefficient, thermal conductivity.

(*d*) *Other Properties:* abrasion resistance, thermal-shock resistance.

Typical combinations of these properties are outlined below when it will be noticed that the problems are many and complex. Service applications can be summarised thus:—

(A) High tensile strength plus moderate creep resistance plus thermal-shock resistance, e.g., extrusion equipment.

(B) Moderate tensile strength at room temperature (say, 50 to 70 tons per square inch) plus good creep resistance, e.g., short-life turbines.

(C) Very good creep resistance plus such tensile properties as are available, e.g., long-term applications such as power turbines for ships and electricity generation.

(D) Fatigue strength, creep resistance, thermal-shock resistance, corrosion resistance, e.g., gas or steam turbine blading.

(E) Corrosion plus creep resistance, e.g., heat-exchanger tubes, reaction vessels.

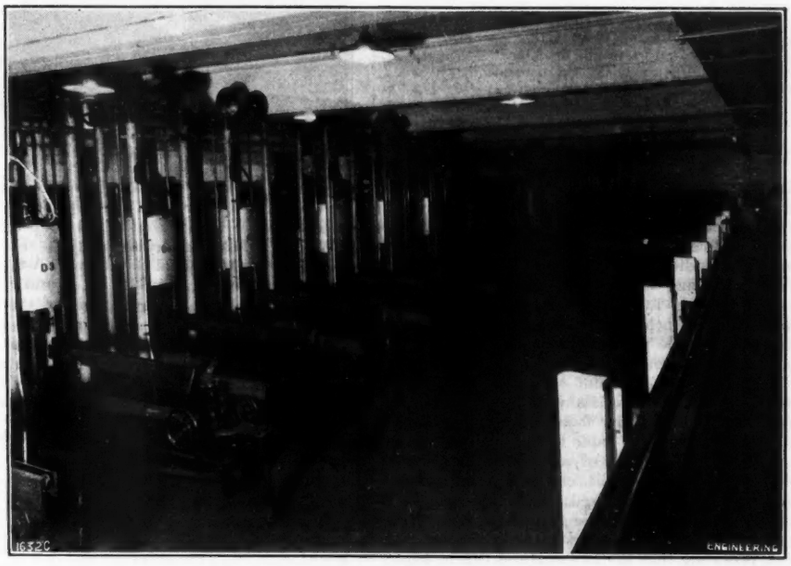


FIG. 3. PRECISION CREEP-TESTING EQUIPMENT.

(F) Impact strength plus creep resistance, e.g., bolts, studs.

(G) Ease of fabrication plus creep resistance, e.g., pipes, flame tubes.

No one material can be supplied which will meet all these requirements, and the relative merits of materials are difficult to evaluate except for a specific application. For example, a material treated to give the maximum creep resistance for turbine-rotor purposes would not necessarily be suitable for extrusion applications because the normal hot tensile strength would be too low.

Choice of Testing Criterion.—The prime variables to be considered in developing materials for creep resistance are: (A) composition; (B) heat treatment; (C) test conditions, i.e., stress, temperature-time deformation; (D) any other relevant factors, i.e., tensile, impact, corrosion, thermal-shock resistance, physical properties.

The factors involved in item (D) will be discussed where relevant in the argument relating to items (A) and (B). The first and most invidious step is to choose the test criterion as such. This may be a test to destruction, or a test to cause a certain deformation, for example, 0·1 per cent. The time factor should preferably coincide with the service period involved, this however may be impractical and a shorter term test employed with considerable error occurring in the resulting extrapolation (see the work of Grant and Bucklin[12]). The stress and temperature can usually be established with a fair approximation to service conditions. In the authors' case a test of 1,000 hours duration at 600 deg. C.

* Paper read before Section G of the British Association at Liverpool, on Tuesday, September 8, 1953.

† Bibliographical references will be given at the end of the paper.—Ed.E.

under a stress of 8 tons per square inch was taken to represent the conditions under which a low alloy steel would operate in an early gas turbine. In this instance, the steel was also required to meet a 60 tons per square inch tensile specification. The creep criterion generally adopted in sorting out alloys in the Hadfield laboratories is the total deformation after a 300 or 1,000 hours test period. The interpretation of these results in terms of much longer service periods, of the order of 100,000 hours or more, can be very misleading, in fact, the choice of 300 instead of 1,000 hours can give a false assessment, see curves 01060 and 01049 in Fig. 2, page 505. However, it is the authors' belief that the conclusions they draw later in this paper, contain the basic principles underlying the constitution effects in the low alloy hardenable steels and with due attention can be applied to longer term applications.

Creep testing calls for rather extensive facilities and views of the Hadfield's laboratories are shown in Figs. 3 and 4. Among the equipment available for high-temperature investigations are the following items :—

Type.	Number.
5-ton capacity precision creep-testing machines	24
½-ton capacity miniature creep-testing machines	24
3-ton capacity rupture-testing machines ...	12
2½-ton capacity stress relaxation machines ...	2
Wöhler-type fatigue machines (miniature) ...	3
Haigh-type fatigue machines (miniature) ...	3

Types of Alloy for High-Temperature Service.

In Table I, examples are given of the principal cobalt, chromium and nickel-based alloys, the heavily alloyed austenitic steels, the simpler stabilised austenitic steels, and various quench hardening steels. An indication of their relative merits is given by quoting the temperature at which they would rupture in 1,000 hours under a stress of 10 tons per square inch. If a different criterion were chosen the relative positions could be considerably modified and in general, if the temperature chosen for operation is below about 550 deg. C., then the quench hardening materials would appear much higher in the list. Other factors than creep have to be considered and in Table II the relative merits of the two main groups of alloys are compared. For this purpose the cobalt, chromium and nickel-based alloys can be classed with the austenitic alloys. It has long been the authors' opinion that the overwhelming advantages lie with the ferritic steels, providing that the temperatures can be kept down by design. The necessity to conserve alloys and difficulties with dollar exchange have added considerable point to these views. In the field of gas-turbine engineering increased practical experience has enabled designers to utilise cooled ferritic rotor forgings in place of the early use of the heavily alloyed austenitic forgings. The improved ferritic alloys now becoming available together with further advances in cooling techniques should lead to rapid developments in many other fields of high-temperature engineering.

Austenitic Steels.—Up till the outbreak of the 1939-1945 War, very few highly alloyed austenitic steels had been developed for high-temperature service. The term "highly alloyed" is intended to describe alloys containing considerable amounts of cobalt, molybdenum, niobium, titanium and vanadium in addition to the nickel and chromium commonly present in austenitic alloys. In fact in 1939 the late Dr. W. H. Hatfield[13] in discussing heat and creep resisting alloys quotes examples of the properties of the standard nickel-chromium alloys, some nickel-chromium-tungsten alloys and one example only of a carbide stabilised steel. The benefits to be derived from further alloy additions were realised and Dr. Hatfield mentioned the possible use of molybdenum, tungsten, titanium, vanadium cobalt, niobium, tantalum, nitrogen and boron for improved creep resistance.

Development of new alloys proceeded rapidly from 1939 onwards under the impetus of the realisation of a successful jet engine by Whittle.[14] Notable contributions were made by Kirkby and Sykes,[15] and Oliver and Harris.[16] Kirkby and Sykes working from the 18/8 titanium-type alloy have produced the well known Rex 78 (alloy 10 in Table I), an alloy containing approximately 18 per cent. Ni, 14 per cent. Cr, 4 per cent. Cu, 4 per cent. Mo, 0·75 per cent. Ti, 0·25 per cent. max. V and 0·12 per cent. max. C. Further developments have included the Rex 337.A type of alloy (No. 5 in Table I), Rex 326 (No. 9) and F.C.B. (T) (No. 11). Oliver and Harris produced the very successful G.18B alloy containing approximately 13 per cent. Ni, 13 per cent. Cr, 10 per cent. Co 3 per cent. Nb, 2·5 per cent. W and 2 per cent. Mo (No. 7 in Table I), and the blading alloy G.32 (No. 2 in Table I). American work proceeded along similar lines with the production of a large number of materials, of which the N.155 alloy is outstanding (alloy 6 in Table I). Other alloys which have been developed include the well known Nimonic series of which Nimonic 75 and Nimonic 80A are represented in Table I as alloys numbers 12 and 4, respectively.

The chromium-based alloys have been studied by Sully and his co-workers, who have studied the melting and casting of chromium-rich alloys,[17] the properties of binary alloys,[18] the properties of ternary and more complex alloys[19] and also the dependence of the ductility of such alloys upon temperature and purity.[20] Sully shows that chromium exhibits a ductility transition temperature under slow as well as impact loading; this transition is above room temperature, and the temperature of the transition is raised by all the alloy additions studied. The lack of ductility is reflected in poor thermal-shock resistance, with the result that despite good creep properties the chromium based alloys seem unlikely to prove commercially useful. (A typical alloy is shown in Table I, No. 3). Recent work in the United States by Grant[21] has produced a number of cobalt-based alloys, an outstanding example being the cobalt-chromium Alloy J (No. 1 in Table I).

CREEP-RESISTING STEELS.

Fig. 4. Miniature Creep-Testing Machines.

Table I.—*Comparison of Creep Properties of Materials Used at Elevated Temperatures.*

Type of Alloy.	Approximate Composition.	Temperature, deg. C., at which Rupture Occurs in 1,000 Hours Under a Stress of 10 Tons per sq. in.
1. Cobalt base	62 Co, 23 Cr, 6 Ni, 6 Mo + Ta, Mn	815
2. Cobalt base	50 Co, 20 Cr, 10 Ni + Mo, V, Nb, Fe	800
3. Chromium base ..	60 Cr, 25 Mo, 15 Fe ..	800
4. Nickel base	70 Ni, 20 Cr, Ti, Al ..	760
5. Ni-Co-Cr-Fe austenitic	18 Ni, 18 Cr, 7 Co, 3 Cu, 3 Mo, Ti	760
6. Ni-Co-Cr-Fe austenitic	20 Ni, 20 Cr, 20 Co, Mo, W, Nb, N_2	735
7. Ni-Co-Cr-Fe austenitic	13 Ni, 13 Cr, 10 Co, W, Mo, Nb	715
8. Nickel base	70 Ni, 30 Mo ..	705
9. Ni-Co-Cr-Fe austenitic	18 Ni, 18 Cr, 7 Co, Mn, Mo, Nb	700
10. Ni-Cr-Cu austenitic	18 Ni, 14 Cr, Cu, Mo, Ti, V	680
11. Ni-Cr austenitic ..	18 Cr, 10 Ni, Nb ..	630
12. Nickel base	80 Ni, 20 Cr (+ TiC)	550
Quench Hardening.		
13. 12 per cent. Cr Mo steel	12 Cr, Mo, V, Ti, Nb, N_2, B	650
14. 3 per cent. Cr Mo steel	3 Cr, Mo, W, V ..	625
15. Mo V steel	0·5 Mo, 0·25 V ..	600
16. Mo steel	0·5 Mo	560
17. Carbon steel ..	0·15 per cent. C. ..	480

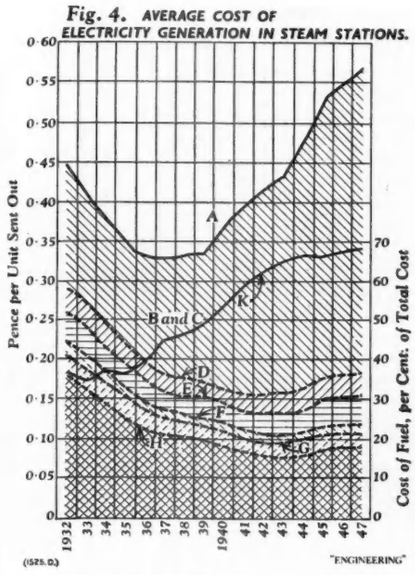
Table II.—*Comparison of Austenitic and Ferritic Materials.*

Property.	Ferritic.	Austenitic.
Forgeability ..	Easy in most cases, more difficult with higher alloys.	Difficult—especially where large articles are required.
Heat treatment	Moderately difficult, problems of scaling, mass effect, hardenability.	Easy—though may be expensive.
Machining ..	Moderate.	Fairly difficult.
Welding ..	Difficult.	Easy.
Elastic limit ..	Moderate to high.	Very low to low, except when age-or work-hardened.
Fatigue	Moderate to high.	Low.
Hot strength ..	Good to about 600 deg. C. Fall off rapidly about 700 deg. C. and above.	Good up to 800 deg. C. Useful up to 1,000 deg. C.
Expansion coefficient	Low 10 to 13 × 10^{-6} per deg. C.	High 14 to 18 × 10^{-6}. per deg. C.
Thermal conductivity	High 0·05 to 0·15 cal. per sq. cm. per sec. per deg. C. per cm.	Low 0·02 to 0·04 cal. per sq. cm. per sec. per deg. C. per cm.
Specific gravity ..	Low 7·5 to 7·8.	High 7·9 to 8·2.
Scaling	Poor unless 12 per cent. Cr present.	Generally good.
Alloy content ..	Low to moderate.	High. Especially Ni and Co.
Cost	Low.	High.

The use of such complex alloys was largely dictated by the necessity to use very high temperatures when oxidation resistance becomes a factor of prime importance. The only inherently oxidation resistant alloys in the ferritic group of steels are those with high chromium or high chromium plus silicon contents, and even as late as January, 1949, it was possible to say that such alloys were inferior in creep properties to the Mo V steel.[22] The austenitic alloys, however, provided a natural basis for the initial intensive development of creep resistance together with oxidation resistance. In recent years, work on ferritic steels has indicated that considerably improved properties can be developed and the next section of this paper will deal with the principal types of ferritic steels, including those having good oxidation resistance.

(To be continued.)

Fig. 4. AVERAGE COST OF ELECTRICITY GENERATION IN STEAM STATIONS.



DISTRICT HEATING.*

By A. E. MARGOLIS, Dipl. Ing.

(*Concluded from page* 475.)

IMPORTANCE OF HEAT-ELECTRIC GENERATION FOR ELECTRICITY SUPPLY.

THE rapidly-growing demand for electric power and the continuing shortage of coal, have focused attention on heat-electric generation as one of the most important and worthwhile methods of meeting this demand with efficient use of fuel. By raising the initial pressure and the temperature of the steam, by decreasing the pressure of the exhaust steam and the introduction of feed-water heating, the thermal efficiency of power generation has been improved to a remarkable extent, but unavoidably most of the heat input of a condensing station is rejected with the cooling water. Owing to the steady increase in cost of fuel, the cost of this waste heat is also increasing. Fig. 4 shows the ever-growing influence of the coal cost on the price of electricity. Curve A shows the average total cost of production per unit sent out; curves B and C, show the cost of fuel and fuel handling; curve D the cost of salaries and wages; E the cost of repairs, maintenance, oil, water and stores; F cost of management; G rates; and H capital charges. Curve K indicates that in 1947 the fuel cost had reached 67·5 per cent. of the total cost of electricity generation, as compared with 34·2 per cent. in 1933. The major part of the heat content of the fuel consumption in power stations is lost as waste heat with the cooling water. This waste cannot be tolerated in this age of steadily rising cost and increasing shortage of fuel.

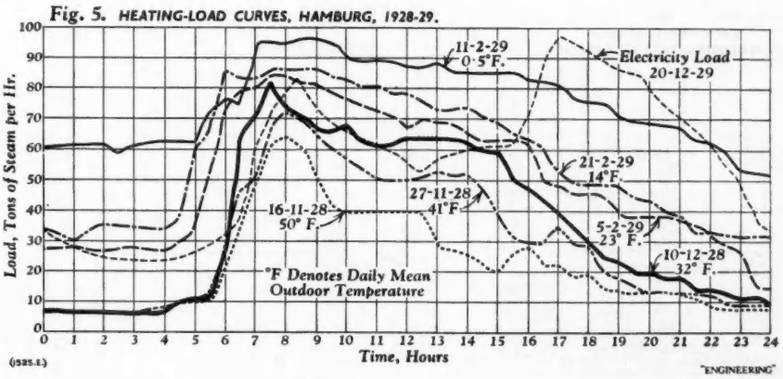
Apart from fuel economy, heat-electric generation will reduce the present peak demands on condensing stations, due to electric heating. No definite data are available on the electricity generating capacity required at present to meet the total demand for space heating in the country, but it is a considerable proportion of the total capacity. At the Conference of the Institute of Fuel on Combined Heat and Power Supplies, 1949, J. N. Waite, M.I.E.E., Divisional Controller of B.E.A., stated that in winter the difference in maximum load between that for relatively warm weather and that for extremely cold weather is in the order of two million kW.† A total load of three million kW can now be assumed to meet the peaks due to electric heating, and this explains the reason for the appeals of the B.E.A. not to use electric heating at peak times.

* Paper read before Section G of the British Association at Liverpool, on Monday, September 7, 1953.

† *Jl. Inst. Fuel*, 1949.

DISTRICT HEATING.

Fig. 5. HEATING-LOAD CURVES, HAMBURG, 1928-29.



It is evident that any increase of the generating capacity to meet the growing requirements of electric heating is neither economical nor in the interest of the fuel economy of the country. Meanwhile, the rather unsatisfactory method of topping-up background heating with gas or electric fires is unfortunately gaining ground, and this encourages the installation of semi central-heating systems which will inevitably create, in years to come, a heavy additional peak demand. The claim of some electrical engineers that electric heating improves the annual load factor is in contradiction to the investigations of the well-known authority, P. Schiller, who found that the heating load reduces the overall annual load factor even more than the lighting load.

The high capital cost of district heating compared with conventional methods, which is mainly due to the cost of central-heating installations, has resulted in the statement that district heating is so expensive that the nation cannot afford it, but in view of the inherent fuel economy it would be more apposite to say that we cannot afford not to have it. The cost of the hot-water accumulator for the Pimlico district-heating scheme, including the total transmission and distribution systems, with the connections to the buildings, amounts to only 25 per cent. of the cost of single electric hot-water storage heaters for approximately an equal storage capacity and balancing effect. In this country, with heat distribution by means of hot water, district heating is the cheapest method of heating and the cheapest method of balancing heat and electricity loads on a very large scale. In addition, the turnover of the power stations can be increased by 80 to 100 per cent.

Balancing of Heat and Power Loads.—The economic range of straight heat supply for district heating is very limited, the capital expenditure for boiler plant is heavy and the operational cost of boilers is comparatively high. Hence, the desire of district-heating engineers to use exhaust steam from power stations is only natural. The theoretical advantages of heat-electric generation cannot be disputed, but it is evident that the problem cannot be solved only from the standpoint of district heating. A back-pressure turbo-alternator is of little value in a power station if its electric capacity is not available during the time of peak load. The saving in fuel is important, but without heat storage the annual load factor of the back-pressure sets used for district heating is only about half that of condensing sets, and the cost of attendance, maintenance and capital charges per unit generated is about twice as high. This explains the rather astonishing fact that, in the United States only, a small proportion, of the order of 10 to 14 per cent., of the steam required for district heating is supplied by exhaust steam. Combined heat and electricity generation on a large scale is only possible if the heat-electric stations can be incorporated in the general system of public power generation. This depends mainly upon the balancing of the heat and electricity loads and upon the increase of the annual load factor of heat-electric stations to that of condensing stations.

The greatest difficulty experienced in the past in combining heat and electricity generation has been due to the variation of the heat and power demands which fluctuate independently of each other. In Fig. 5 the heating loads in Hamburg are shown which are typical for an office area. The load curve for an outdoor temperature of 32 deg. F., which is nearest to the maximum-load conditions in this country, is indicated by a heavy line. The heavy dotted line shows the comparative fluctuation of the electricity load. The curves demonstrate that the peak demands of heat and power generation do not coincide; neither is there conformity in the fluctuation of the loads. The heat demand on mild days during the electricity peak in the evening is so small that the back-pressure sets cannot be put into operation and the heat has to be supplied by live steam. In a residential area the daily load curves are flatter, but the great divergency of the heat and electricity loads, especially on mild days, remains. It is significant that the heat supply can be stopped overnight even on comparatively cold days. The methods adopted for balancing the heat and power loads are indicated in Fig. 6, page 508, and are as follows:—

Method a.—By back-pressure sets and low-pressure condensing sets working in parallel. This is the usual but the most expensive method because the capacity of the back-pressure sets cannot be used on mild days at the time of the electric peak load and the load factor of these back-pressure sets is comparatively poor. The main disadvantage is that the cost of the back-pressure sets and the cost of the additional boiler capacity has to be allocated entirely to district heating.

Method b.—By back-pressure sets and low-pressure condensing sets in series. The exhaust steam of a back-pressure set when not required for heating is passed out to a low-pressure condensing set. This method improves considerably the annual load factor and value of the back-pressure sets and the additional cost of a low-pressure condensing set is much lower than that of a high-pressure independent condensing set operating in parallel.

Method c.—By the use of pass-out steam turbines as are extensively employed in the Soviet Union. The cost of pass-out turbo-alternators is lower than that of separate condensing and back-pressure sets. The overall steam consumption owing to the variation of the heating and power loads is, however, much higher than with back-pressure sets.

Method d.—By hot-water storage combined with any form of heat-electric station. Heat storage in large capacity hot-water accumulators introduced by the author, is the most efficient method of balancing the variation of heat and power loads. Both services can be run independently of each other; the capacity of the boilers and of the back-pressure sets can be considerably reduced and the annual load factor of the power station is considerably increased. In fact, the introduction of the large capacity hot-water accumulator has completely changed the economic position of district heating. A heat-electric station without heat storage is comparable with a gasworks without gasholders.

DISTRICT HEATING.

Fig. 6.

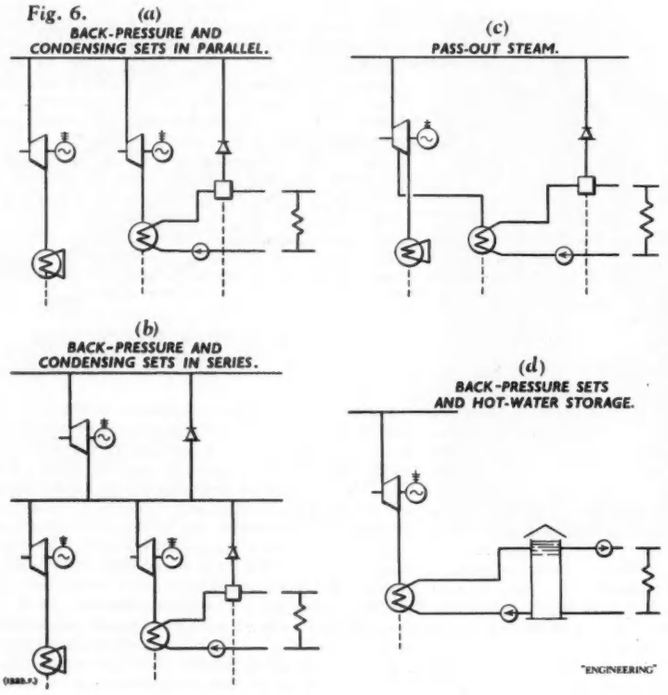
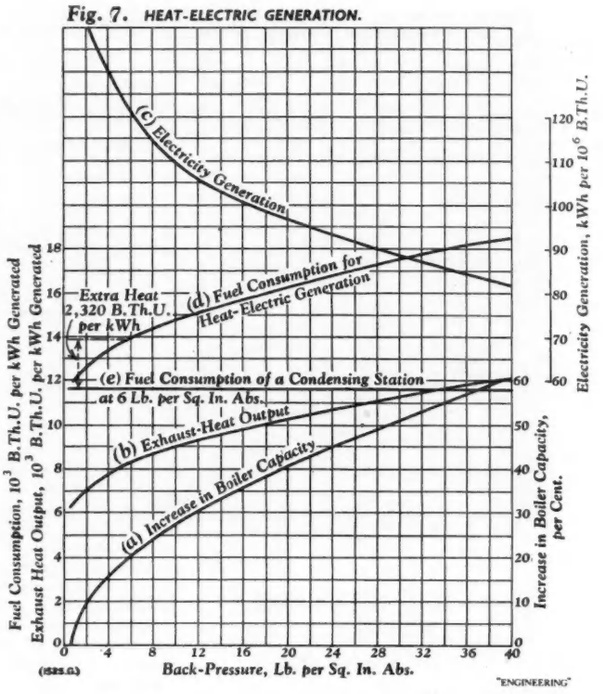


Fig. 7. HEAT-ELECTRIC GENERATION.


(c) Electricity Generation
(d) Fuel Consumption for Heat-Electric Generation
Extra Heat 2,320 B.Th.U. per kWh
(e) Fuel Consumption of a Condensing Station at 6 Lb. per Sq. In. Abs.
(b) Exhaust-Heat Output
(a) Increase in Boiler Capacity
Fuel Consumption, 10³ B.Th.U. per kWh Generated
Exhaust Heat Output, 10³ B.Th.U. per kWh Generated
Increase in Boiler Capacity, per Cent.
Electricity Generation, kWh per 10⁶ B.Th.U.
Back-Pressure, Lb. per Sq. In. Abs.
"ENGINEERING"

Progress in District Heating Engineering.

Progress has been made possible mainly by: (*a*) the adoption of high-pressure steam for electricity generation; (*b*) the introduction of the large-capacity hot-water accumulator for storage of exhaust heat and electric thermal storage; and (*c*) improvements in heat distribution and transmission.

(*a*) A high initial steam pressure for heat-electric generation is even more important than for condensing stations because of the comparatively greater increase of the adiabatic heat drop. Fig. 7 shows the conditions of heat-electric generation with steam of 900 lb. per square inch abs., 900 deg. F., an efficiency ratio of 80 per cent., regenerative feed-water heating to 400 deg. F., and a boiler efficiency of 85 per cent. The graph demonstrates the importance of reducing the back-pressure on the turbines as much as possible. Fortunately, heating installations in this country are run with moderate flow-water temperatures and the back-pressure turbines can be operated with an average back-pressure of about 6 lb. per square inch abs. On mild days and in summer, the back-pressure can be reduced. When on cold days a higher flow-water temperature is required, the back pressure from the turbines can be increased during the night and the temperature of the stored heating water raised to 180 deg. F. or even to 200 deg. F. if required. During the day time, however, the turbines can be run with an average back pressure of 6 lb. per square inch abs., or lower, to ensure a greater electricity output. This method of operation makes the plant very flexible to meet the variations of the heat and electricity demands.

Curve (*a*) shows that at a back-pressure of 6 lb. per square inch abs., the increase in boiler-plant capacity, as compared with condensing sets operating with 28·5 in. vacuum, amounts to only 20 per cent. The increase in cost for the larger boiler plant is less than the saving in the costs of back-pressure turbines and condensers in a heat-electric station. At a back-pressure of 6 lb. per square inch abs., the volume of the steam is about 62 cub. ft. per lb. as compared with 437 cub. ft. at 28·5 in. vacuum, thus reducing the size of the low-pressure blades and condensers. The cost of a heat-electric station for low-temperature hot-water distribution is therefore lower than that of a condensing station with cooling towers. Curve (*b*) shows that at a back-pressure of 6 lb. per square inch abs., with an efficiency ratio of 80 per cent. the exhaust-heat output amounts to 8,210 B.Th.U. per kWh. Curve (*c*) indicates that at this back-pressure 122 kWh per 10^6 B.Th.U. exhaust-heat supply can be generated. Finally, curve (*d*) shows the fuel consumption of heat-electric generation in accordance with the back-pressure, and the straight line (*e*) the fuel consumption of condensing sets, both at a boiler efficiency of 85 per cent. Curve (*d*) demonstrates the fact that for the generation of 1 kWh at a back-pressure of 6 lb. per square inch abs., together with 8,210 B.Th.U. per kWh exhaust heat, a fuel consumption of 13,900 B.Th.U. per kWh is required, which is only 2,320 B.Th.U. more than with a condensing set at 28·5 in. vacuum. It means that the extra consumption of fuel for the generation of 8,210 B.Th.U. exhaust heat amounts to only 2,320 B.Th.U. per kWh, or to 28,200 B.Th.U. per therm, equal to 28·2 per cent. of that for straight heat supply.

(*b*) The introduction of the large-capacity hot-water accumulator has solved the problem of balancing the heating and electricity loads in a perfect way. Any surplus or deficiency of exhaust heat is made good by storage of the heat in the form of hot water and both services can thus be run independently of each other. The total demand for heat can be supplied by exhaust heat without any admixture of live steam. In the past the back-pressure sets could not be operated at times of low heating load, as in the afternoon or evening on mild days, to meet the requirements of electricity generation. Therefore, the capital charges and the operational cost of the back-pressure sets had to be allocated entirely to district heating and they often exceeded the cost of fuel saved. The introduction of the large-capacity hot-water accumulator has also considerably improved the annual load factor of the heat and electricity generating plant for district heating. To-day a heat-electric station can be operated with a much higher annual load factor, equal to that of an average condensing station. The operation in summer is of course limited mostly to one shift.

The useful heat-storage capacity of a hot-water accumulator is about 5,000 B.Th.U. per cubic foot. For storage of the exhaust heat of a modern heat-electric station the maximum storage capacity to meet all variations of the heating and electricity loads can be assumed at 12 cub. ft. per kWh generating capacity installed which permits the operation of the back-pressure sets for six hours without any heating load at all. The capital cost of the accumulators including insulation for a large heat-electric station amounts then to about 3*l*. per kilowatt generating capacity, which is approximately equal to the cost of cooling towers. When installed at sub-stations in the centres of the heat-distribution systems, the cost of the accumulators can be allocated to the capital expenditure of heat transmission and distribution. It should be noted that the heat losses of large capacity hot-water accumulators are exceedingly low, owing to the favourable surface-volume ratio. For the Pimlico accumulator the annual heat losses have been estimated and confirmed by tests at less than 1 per cent. of the annual heat consumption. For large heat-electric stations the annual heat losses of the hot-water accumulators would not exceed 0·5 per cent. of the annual heat consumption. It should also be noted that for the storage of the same quantity of useful heat with town gas the volume of a gasholder is about 20 times as large as that of a hot-water accumulator.

(*c*) The dimensions, the heat losses and the costs of heat-transmission and distribution mains can be considerably reduced by an increase of the temperature drop of the circulating heating water. This is made possible by the introduction of ejectors for admixture of return water to the heating flow of the radiator systems by which the temperature drop between the district-heating flow and return can to-day be conveniently increased to say 80 deg. F. instead of an average drop of 25 deg. F. previously used for central-heating systems. The heat-carrying capacity of the mains is increased in proportion to the temperature drop and the heat losses are correspondingly reduced. The sizes and heat losses of transmission mains can be further reduced by hot-water accumulators in the centre of the heating loads.

Saving of Fuel by Heat-Electric Generation.—It is not realised yet how much coal can be saved by the adoption of heat-electric generation. Under the present conditions we need for the conventional methods of heating to domestic consumers at an average thermal efficiency of 30 per cent., a fuel consumption of 333,000 B.Th.U. per therm. In a modern heat-electric station with an initial steam pressure of 900 lb. per square inch, 900 deg. F., and

DISTRICT HEATING.

Fig. 8. PIMLICO DISTRICT-HEATING SCHEME.

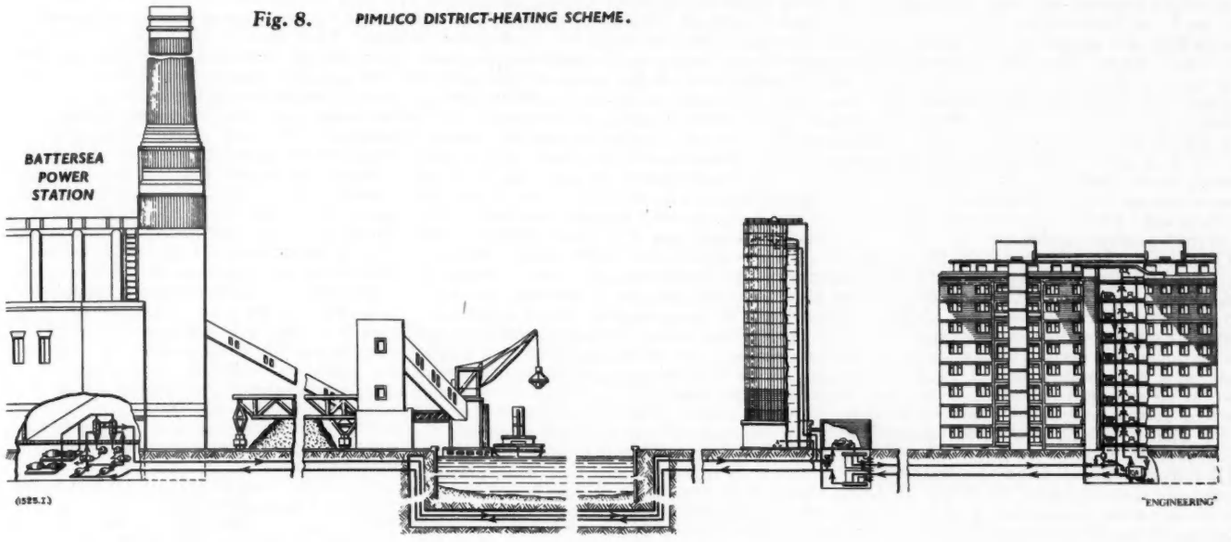


Fig. 9. SECTION A-A

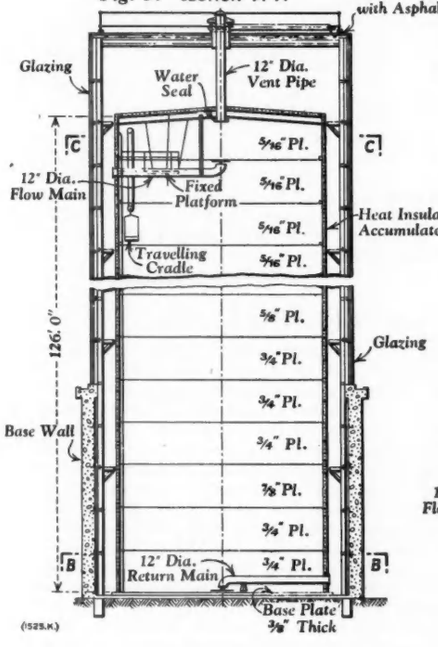


Fig. 10. SECTION B-B

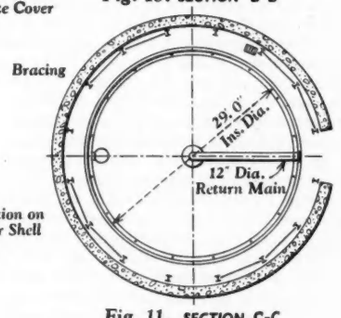


Fig. 11. SECTION C-C

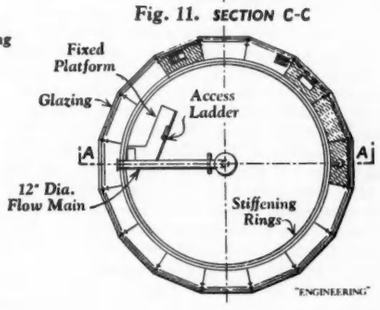


Fig. 12.

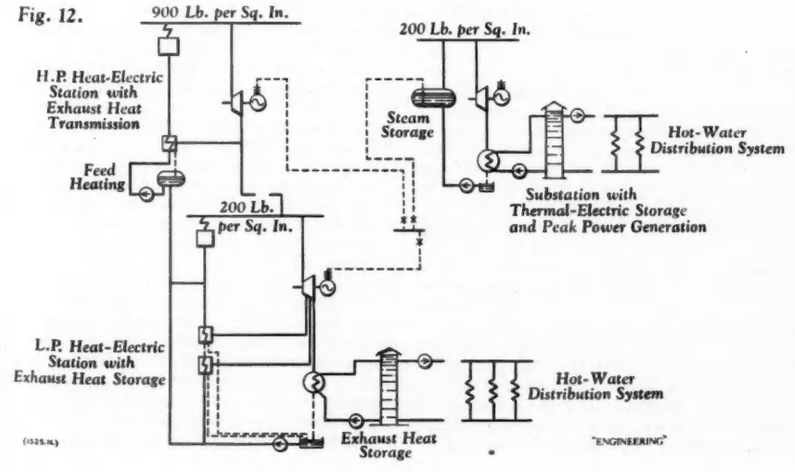
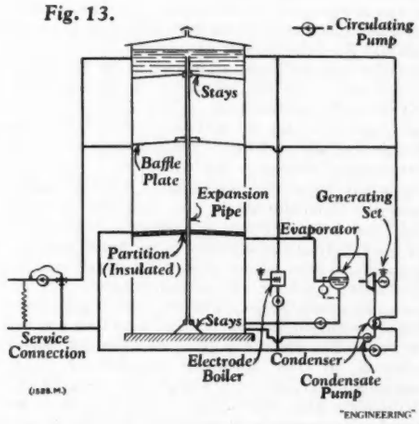

900 Lb. per Sq. In.
200 Lb. per Sq. In.
H.P. Heat-Electric Station with Exhaust Heat Transmission
Steam Storage
Hot-Water Distribution System
Feed Heating
Substation with Thermal-Electric Storage and Peak Power Generation
200 Lb. per Sq. In.
L.P. Heat-Electric Station with Exhaust Heat Storage
Hot-Water Distribution System
Exhaust Heat Storage
"ENGINEERING"

Fig. 13.



an average back pressure of 6 lb. per square inch abs., the extra fuel consumption for heat supply amounts to only 2,320 B.Th.U. per kilowatt-hour for 8,210 B.Th.U. of the exhaust-heat output of 1 kWh, or to 28,210 B.Th.U. per therm. With an allowance of 15 per cent. for transmission and distribution losses the extra fuel consumption for the heat supply at consumers' premises is increased to 33,000 B.Th.U. per therm and the fuel consumption of 300,000 B.Th.U., or three therms per therm of the heat supply, will be saved. It must be particularly stressed that the saving in coal in heat-electric stations will by far exceed the additional quantities of coal required in new condensing stations for the same generating capacity. On the average a heat-electric generating capacity of 1 million kW will save the coal consumption of approximately 2 million kW condensing capacity.

Pimlico District Heating Scheme, Westminster.—This scheme incorporates the advanced engineering methods of heat-electric generation and heat distribution. It is now in operation with about half of the final heating load. It is a small beginning, but of great significance for the future large-scale development of district heating with heat-electric generation. It should be noted that it is the first district-heating scheme in the world solely with exhaust-heat supply. No live steam is required, neither at peak time of the heating demand, nor for balancing the variations of the electricity and heating loads. This development has been made possible by the foresight of the Westminster City Council in adopting for their new housing estate a district-heating service, and to Mr. S. B. Donkin, the consulting engineer for the district-heating scheme, for developing it.

The Pimlico housing estate covers an area of about 33 acres and when completed will provide about 1,640 dwellings in 51 blocks, giving a density of about 50 dwellings per acre. The majority of flats are in tall blocks, eight, nine, ten and eleven storeys high and consist of two, three, four and five rooms. To the east of the housing estate the large block of flats, known as Dolphin Square, is situated, which contains 1,220 dwellings and this is also supplied from the system. Meanwhile, the Westminster City Council have decided to extend the supply of heat to the Warwick Way housing estate, with 280 dwellings. On completion of both estates, together with Dolphin Square, about 3,200 dwellings and a number of communal buildings will be served by district heating.

The maximum heat demand of the Pimlico housing estate for space heating was estimated for design temperatures of 65 deg. F. in the living rooms and 55 to 60 deg. F. in the bedrooms, kitchens and bathrooms, with an outdoor temperature of 30 deg.F. The maximum heat demand for hot tap water was based on a daily consumption of 15 gallons per head, at an average temperature of 130 deg. F. The total maximum demand for heat for the whole of the Pimlico housing estate was estimated at about 45×10^6 B.Th.U. per hour and, including Dolphin Square, Russell House and Warwick Way housing estate, at about 80×10^6 B.Th.U. per hour. The general outline of the scheme is shown in Fig. 8, page 509. From Battersea power station on the left the heat is transmitted to the hot-water accumulator at the sub-station on the right of the figure, and from here distributed to the buildings of the housing estate. For circulating the heating water two sets of pumps are provided, one set at the Battersea power station for the heating water to and from the hot-water accumulator on the housing estate, the other set at the sub-station for circulating and distributing the heat to the space-heating and hot-water supply systems in the buildings.

For the supply of heat, two 1,350-kW back-pressure turbo-alternators are installed in the Battersea power station as additional house sets for the supply of the auxiliary power in the station. The exhaust-heat output of each set at full load is 227 therms per hour with a back-pressure of 2 lb. per square inch gauge. For the heat supply two sets are sufficient, because on cold days they can be run over 24 hours and the variation of loads balanced by the hot-water accumulator. The accumulator consists of a cylindrical vessel, 29 ft. in diameter and 126 ft. high. The hot water is stored at atmospheric pressure and the vessel serves also as an expansion tank for the total volume of water required for the heating system. The same water is continuously in use and the initial fill and any make-up water is chemically treated to prevent any corrosion and scale or deposits in the pipe-work and in the heat exchangers at the power station. The useful storage capacity at a temperature difference of 70 deg. F. amounts to about 3,500 therms, but it is likely that a temperature difference of 80 deg. F. will be attained, thus increasing the storage capacity to about 4,000 therms. The accumulator is protected against heat losses with cork lagging 3 in. thick, and the annual heat losses amount to only about 1 per cent. of the total final annual heat consumption. The accumulator is charged and discharged automatically according to the available supply and demand respectively for heat. The construction of the accumulator is shown in Figs. 9, 10 and 11. The shell consists of 21 courses of plates, $\frac{7}{8}$ in. thick at the bottom and of $\frac{1}{16}$ in. thickness at the top. It is erected on a concrete foundation which also supports a steel-frame enclosure with $\frac{1}{4}$-in. thick glass panes, set in aluminium glazing bars. The outer appearance of the accumulator harmonises well with the architecture of the blocks of flats.

The heat supply to the radiator systems of the Pimlico housing estate is thermostatically controlled by the variation of the flow-water temperature. The thermostat is set at the required temperature in accordance with the weather conditions and the temperature is maintained constant by a mixing valve in the pump house at Pimlico regulating the quantity of flow water from the Battersea power station or from the accumulator by an admixture of return water from the estate heating system. The correct setting of the thermostat is determined by means of distance thermometers indicating and recording the air temperature in a number of typical living rooms on the estate. In the pump house a panel is provided carrying all the indicating and recording instruments which are required for the operation and control of the district-heating plant.

On completion of the scheme a population of about 11,000 will be served by district heating. At least 10,000,000 kWh of electricity will be generated annually by the heat-electric generating plant at Battersea, with an overall thermal efficiency for the generation of heat and electricity together of about 80 per cent. About 11,000 tons of coal would be saved annually as compared with the fuel consumption of the central-heating boilers in Dolphin-square and Russell House, and with the present conventional methods of heating by coal fires, electricity or gas for the buildings of both estates for the same quantity of heat supplied.

Double Heat-Storage System.—Exhaust-heat storage increases the annual load factor of a heat-electric station, but an appreciable quantity of power is generated in the off-peak time, mainly during the night. Only a proportion of the night power can be absorbed for general purposes; the bulk of the output will have to be used for heating purposes by means of electric thermal storage. This leads to the system of double heat storage; firstly, of exhaust heat at the generating station or sub-stations for the districts which can be served from the power station, and secondly, of electric thermal storage for districts which are too far away from a power station to be served by exhaust heat. By the system of double heat storage a complete co-ordination of generation and supply of heat and electric power can be attained.

The heat supply can be extended to isolated groups of buildings by means of hot-water accumulators heated by electrode boilers. In the case of an industrial group of buildings a proportion of the heat can be supplied with high-temperature hot water for process work which is stored in the lower part of the hot-water accumulator at a suitable pressure and temperature which are balanced by the height of the low-temperature water column above, as shown in Figs. 12 and 13, page 509. The double-storage system increases the flexibility of district heating to suit the various requirements of heating and also of process work with moderate temperatures. Under favourable local conditions it is possible to store high-temperature hot water for steam generation to be used for electricity generation as by a battery of Ruth accumulators, as indicated in Fig. 13 with subsequent storage of exhaust heat for hot-water heating. The steam consumption is higher than with Ruth accumulators but the exhaust heat is fully utilised. The electricity output is of course limited by the permissible height of the hot-water accumulator and the consequent permissible temperature of the heating water in the lower compartment. The electricity output per unit of storage volume is reduced but the total output is considerably increased as compared with a Ruth accumulator, because of the huge volume of the high-temperature hot water. Owing to the favourable surface-volume ratio and the complete utilisation of the exhaust heat the cost of peak-power generation is reduced to a minimum. Similarly the capital cost and the heat losses of the plant are reduced.

Conclusion.—Time and space do not permit me to deal fully with the problem of future co-ordination of heat-electric generation. The problem by itself is scientifically sound and the great potentialities of co-ordinated heat-electric generation for the economy of this country cannot be disputed. At an average domestic consumption of 600 therms annually some $75{,}000 \times 10^6$ kWh might be generated in the future in heat-electric stations for residential purposes only, which is, say, 30 per cent. more than the total electricity supply demand under present conditions. Looking ahead we can visualise a time when no burning of coal inside towns will be required as outlined in the previously mentioned contribution of the author to the 1942 Conference: "Improvement of Climatic and Living Conditions by Public Heat Supply." This development will involve, however, a very great amount of investigating work, problems of reorganisation and of co-ordinated planning and a considerable capital expenditure. The greatest part of the capital required is not for district heating but for central-heating installations not already provided which is due to the neglect of scientific development in the past. After the 1914-18 war the majority of new dwellings in Holland, Switzerland and Germany were equipped with central heating but in this country central heating for dwellings is even to-day considered as a luxury and the new towns are being built with all kinds of coal fires. The general trend towards improved heating installations cannot, however, be stopped and the additional cost of central heating will finally have to be debited to the cost of houses. We live in a time of continuous evolution and new dwellings are built for a lifetime of at least 60 years. It is really amazing that planners do not look ahead and plan to meet the steady growing requirements for comfort, health and beauty for the generation to come. What we need is to take quick action and to endeavour to adapt our heating installations to the already existing pattern of scientific development of heat-electric generation of the Pimlico district heating scheme for the City of Westminster. An annual saving of 20 million tons of coal should be our aim which is only a modest figure when compared with the present great waste of coal.

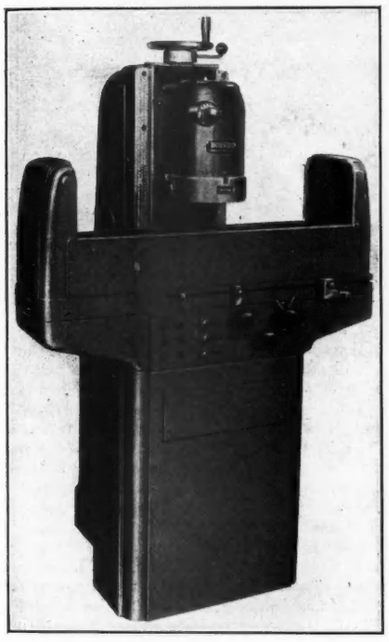
Meanwhile, most of the damaged buildings in Hamburg have been restored and the heat output of the stations, including the new heat-electric stations at Harburg, has increased in the last year to 34,000,000 therms. The great popularity of district heating in Hamburg is demonstrated by the fact that last year the total new load, on the hot-water system only, amounted to 80,000,000 B.Th.U. per hour, which is approximately equal to the total load on the Pimlico undertaking when fully developed. A notable fact is that the costs of the connections and of all apparatus required in the buildings are now being met by the consumers. It may also be mentioned that a very large extension to the district heating system of Charlottenburg was commenced in 1952. Three back-pressure turbo generating sets, each of 50 MW, are to be installed. The delivery of the first set is scheduled for the spring of 1955.

STEELMAKING IN EUROPE.

The annual rate of production of steel ingots and castings in Belgium, France and Western Germany has tended to decline this summer, but, in the United Kingdom the output in each month of 1953, up till the end of August, has broken the all-time record for the particular month, although by diminishing margins in the more recent months. It is shown in the twelfth issue of the *Quarterly Bulletin of Steel Statistics for Europe*, obtainable, price 7*s*. 6*d*., from H.M. Stationery Office, that 63,084,000 metric tons constituted the annual rate of production in the "free" countries of Europe during the second quarter of 1953, compared with 66,356,000 tons in the first quarter of 1953 and 63,950,000 tons in the second of 1952. The estimated rate of steel production for Czechoslovakia, Poland, Eastern Germany, Hungary and Roumania during 1952 was 10,747,000 metric tons; for the U.S.S.R. it was 34,500,000 tons. The annual rate of steel output of the United States during the second quarter of 1953 is given, for comparison, as 105,044,000 metric tons. As regards foreign trade in raw materials during the second quarter of 1953 compared with the corresponding quarter of 1952, the statistics reveal that the imports of scrap of the United Kingdom, at 248,000 tons, were almost half as high again as in 1952, while Italian imports, at 191,000 tons, rose by 6 per cent. The iron-ore imports of Western Germany, Italy and the United Kingdom all increased by approximately one seventh. The increase in German imports was accounted for by intensified arrivals from Norway, North Africa, Brazil, India and Portuguese India; arrivals from Sweden, on the other hand, declined. The increase in Italian iron-ore imports was attributable to greater Portuguese and Spanish Moroccan shipments and the increased British imports came mainly from hitherto untapped sources in Portugal, Brazil, Liberia, West Africa, and Malaya.

SURFACE GRINDING MACHINE.

THE accompanying illustration shows a vertical-spindle type of surface grinder which has recently been introduced by Bourdon Tools, Limited, Union-road, Croydon. It is to be known as the model P.M.2, and has been designed for quantity production of small components and maintaining a high degree of accuracy. It is claimed that the degree of flatness can be held within 0·0002 in. over the working area of the table, which is 42½ in. long by 11 in. wide, with a travel of 25½ in. and a feed rate of 0 to 25 ft. per minute. The micrometer feed and dial, which can be seen at front of the head in the illustration, are graduated in 20 divisions placed about ⅜ in. apart; each division represents an adjustment of 0·00025 in. in the height setting of the grinding head. The handwheel at the top of the head provides the rapid feed for setting, and a friction type of clutch operated by a lever shown



beneath the handwheel locks this feed, while the dial for the micrometer feed can still be adjusted after the rapid feed has been locked.

The castings used on the machine are produced in the company's own foundry, cast iron being the main material of construction. The grinding head slides on gibbed bearing surfaces, and the motor is mounted behind the head to act as a counterbalance. The head can be tilted 2 deg. on either side of the vertical for the purpose of cross-grinding or producing a slightly concave surface. The spindle, which carries the grinding wheel, is made from an alloy steel and hardened and ground all over. The bearings which support it are mounted in such a way that they allow for any expansion that may occur when the machine has been in operation for a while. These bearings are placed immediately above the grinding wheel, and the top end of the spindle is mounted in a simple roller bearing. The pulley driving the spindle is arranged so that its bore does not rest on the spindle, the drive being transmitted through two oversize woodruff-type keys extending from the spindle key-way to the key-way of the pulley wheel. The outer hub of the pulley runs in twin ball journal bearings which are mounted in one of the head castings. A direct torque only is transmitted by this arrangement and all other stresses or vibrations are eliminated. The drive to the spindle is from a 2-h.p. continuously-rated motor through a V-belt, and the spindle is lubricated by grease.

The table of the machine is supported on square shears fitted with a long tapered gib for adjustment for wear. The top surface of the table is ground by the machine upon which it is fitted prior to dispatch. The sliding and bearing surfaces are hand scrapped and they are covered by a collapsible type of blind which permits the table and its base to be made to the same length. The slides are lubricated by oil. The drive used on the table is of the constant-volume hydraulic type and the pressure is supplied by a gear pump driven from a 1-h.p. motor. This provides rapid return of the table for the non-cutting stroke. Trip dogs are fitted, as shown in the illustration, for setting the length of table movement and the control knob can be pulled out to release the movement and also used for inching the table. The other controls, including starter buttons and indicator lights, are neatly arranged on a panel in front of the machine.

The coolant pump and tank are housed in the base of the grinder and a submerged type of pump is employed. An interesting feature of the cooling arrangement adopted is the fact that the fluid is supplied to the inside of the grinding wheel. To prevent the coolant passing through the pores of the grinding wheel, the inner surface of the wheel has to be specially coated and the makers supply the substance for coating new wheels so that any standard wheels can be purchased. This arrangement enables the fluid to be sprayed over the surface being ground andpass out across the surface of the component due to centrifugal action, thus ensuring cool operation. Surface finishes of less than 5 micro inches have been obtained.

The grinding capacity of this machine is 20 in. by 6 in. by 10 in. under the wheel, and increases to 12½ in. The size of the grinding wheel is 6 in. diameter with a bore of 5 in. and a depth of 2 in., which it is stated, can be used to within a depth of ⅜ in. before a replacement wheel is required. Its speed is 2,800 r.p.m. All three motors are arranged for a three-phase alternating-current supply. The overall dimensions of the machine, allowing for the travel of the table, are 68 in. wide, 29 in. from front to back, and 68 in. high. It has a net weight of 14½ cwt.

ANNUALS AND REFERENCE BOOKS.

Servicing Guide to British Motor Vehicles, Vol. 2.

By J. N. MCHATTIE, A.M.I.Mech.E., M.S.A.E. Trader Publishing Company Limited, Dorset House, Stamford-street, London, S.E.1. [Price 42s. net; 43s. 6d., including postage.]

THE information presented in ready-reference form in this book relates to 23 British motor vehicles—cars, commercial vehicles and tractors—which were introduced in 1951 and 1952. The service data sheets of which the book consists appeared originally as supplements to *Motor Trader*. Though intended primarily for the information of repairers and service men in the motor trade, they are also appropriate to the needs of students of motor-vehicle design. The information, in content and arrangement, is uniformly presented for the different models, and includes "telegraphic" descriptions of the designs and servicing operations, as well as drawings of the principal components, various sketches and tabulated data. There are also an illustrated glossary of terms used in the text, a list of alternative part names, and some conversion tables. Volume I deals with earlier vehicles.

The Instrument Manual.

Second Edition. United Trade Press, Limited, 9, Gough Square, Fleet-street, London, E.C.4. [Price. 84s.]

THIS is the second edition of a book the object of which is to provide a full review of British instrumentation. It differs from its predecessor in the omission of the sections on patents and general trends in instrument design, the first in order to avoid duplication (since this matter is already dealt with elsewhere) and the second because the information is given in the other sections. New sections covering aeronautical, navigational, meteorological, surveying and nucleonic instruments have been introduced, as well as on the measurement and control of conductivity and viscosity and on telemetering. The sections on optical instruments and measurement of fluid flow and hydrogen ion concentration, as well as on general electronic instruments and automatic control, have been re-written and the remainder extensively revised. The information given in each section is clearly written and well illustrated and is accompanied by a bibliography and buyers' guide. The whole should form a useful work of reference on an important subject.

CONTRACTS.

HENRY ROBB LTD., Victoria Shipyard, West Pier, Leith, 6, have obtained a contract from the Railway Executive for a single-screw twin-grab hopper dredger for work in Lowestoft Harbour. The vessel will be Diesel-engined driven and the two dredging cranes and grabs will be supplied by PRIESTMAN BROS. LTD., Hull.

Two years after supplying and installing 33-kV cables between Salt River power station, Cape Town, and two new substations at Oakdale and Elsies River, BRITISH INSULATED CABLES (SOUTH AFRICA) LTD., an associate company of the British Insulated Callender's Cables Group, have been awarded an extension to the contract. This involves 66-kV cables of the impregnated pressure type and will carry a further 43 MVA per feeder between Salt River and Oakdale. Two new 66-kV cables will be laid between Salt River power station and Oakdale substation, a distance of approximately 11 miles, and a further 33-kV cable between the power station and Elsies River, approximately seven miles away.

MARCONI'S WIRELESS TELEGRAPH CO., LTD., Chelmsford, Essex, have received an order from the British Broadcasting Corporation for four complete television outside broadcasting units. Each unit will be equipped with five cameras for any type of outside broadcast and with controls and mixers for both vision and sound. Three of the cameras will be used normally for programme purposes, one will be kept ready as a spare if needed, and one as a "pool" of spare parts for maintenance. The vehicles on which the units will be mounted will be self-propelled with the body, cab and engine all built on to one chassis. They will have an overall length of 22 ft., a height of 10 ft., and a statutory width of 7 ft. 6 in.

THE CALEDON SHIPBUILDING AND ENGINEERING CO., LTD., Caledon Shipyard, Dundee, have obtained an order for a twin-screw motorship for the Commissioners of Northern Lighthouses. The propelling machinery will be supplied by BRITISH POLAR ENGINES, LTD., and will be installed by the builders.

DAVY AND UNITED ENGINEERING CO., LTD., Park Iron Works, Sheffield, 4, have secured contracts valued at 4*l*. million for rolling-mill equipment for installation in South Wales. These have been placed jointly by Richard Thomas and Baldwins Ltd., and the Steel Company of Wales, Ltd., and constitute the basis of a new large-scale modernisation project for the Welsh sheet and tin-plate industry. The principal units include a new five-stand tandem cold-strip rolling mill and a two-stand temper rolling mill for the Ebbw Vale plant of Richard Thomas and Baldwins Ltd., and a further five-stand tandem cold-strip mill and two two-stand temper mills for installation in the new Velindre tin-plate works of the Steel Company of Wales, Ltd., near Swansea. The firm's two subsidiary concerns, DUNCAN STEWART & CO., LTD., Glasgow, and DAVY AND UNITED ROLL FOUNDRY, LTD., Middlesbrough, will share in the orders.

TRADE PUBLICATIONS.

Cargo Handling.—An illustrated and descriptive catalogue of mechanical handling equipment for docks and warehouses has been published by Steels Engineering Products, Ltd., Crown Works, Sunderland. Mobile cranes for rail or road are listed, with capacities from 6 to 20 tons, as well as cargo-cranes with hook radii up to 50 ft. An electric tractor and various models of electric trucks are also described.

Flexible Doors.—A leaflet issued by Superbuilt Products, Ltd., Bell Works, Harefield, Middlesex, describes their reinforced-rubber flexible doors. Formed like a pair of curtains, a man or truck simply pushes between them.

Automatic Control Equipment.—Teddington Industrial Equipment, Ltd., Sunbury-on-Thames, Middlesex, have published a catalogue describing their electrically-operated automatic control equipment. Mechanical units are made for operating valves or supplying a torque of 200 lb.-in., as well as pressure or temperature controllers. Typical circuits and applications are given.

Woodworking Machines.—We have received an illustrated pamphlet from Wadkin, Ltd., Green Lane Works, Leicester. It describes some of their machines specially designed for the woodworking industries. Among these is a double-ended tenoner, an 8-in. by 4-in. moulder, and a bandsaw filer and setter.

Cutters for High-Tensile Wire.—A leaflet published by Industrial Diamond, Ltd., Zürich, Switzerland, and issued in this country by O. A. Volkmann, 3, St. Augustine's-road, Edgbaston, Birmingham, 16, describes the Vogt wire-cutting shears. The sliding blade is operated by a rack movement, and each blade has eight cutting edges. Spare blades are obtainable.

Locked-Coil Ropes.—We have received a brochure from British Ropes, Limited, Doncaster, describing their

series of locked-coil wire ropes for colliery and general engineering purposes. The form of stranding used gives a smooth exterior surface, with, consequently, a greater resistance to wear by friction, and also a reduced tendency to spin or stretch, than is the case with the normal stranded rope. These attributes make ropes of this form of construction suitable for winding cages in collieries and for aerial cable-ways.

X-Ray Films for Industrial Radiography.—Ilford Ltd., St. Albans-road, Watford, Hertfordshire, have sent us a booklet giving details of their X-ray films for industrial radiography. Information about screens and chemicals for the same purpose is also given.

Lighting Fittings.—A leaflet issued by Benjamin Electric, Ltd., Brantwood-road, London, N.17, gives brief descriptions of their electric light fittings, together with lighting specifications.

Moulded Plastics.—The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, have published an illustrated booklet describing their moulded plastics for industrial uses. Thermosetting, thermoplastic and bituminous mouldings are described.

Coal Preparation Plants.—Simon-Carves, Ltd., Stockport, have sent us an illustrated booklet discussing the problems of sorting and cleaning coal. Descriptions are given of plant and of installations the company have equipped, and the notes are accompanied by flow sheets for colliery surface-works of various capacities.

Mechanical Stokers.—A pamphlet issued by Hope's Heating and Engineering, Ltd., Smethwick, Birmingham, states the advantages of mechanical over hand firing. Stokers are made with capacities of from 25 to 1,200 lb. of coal per hour.

BRITISH STANDARD SPECIFICATIONS.

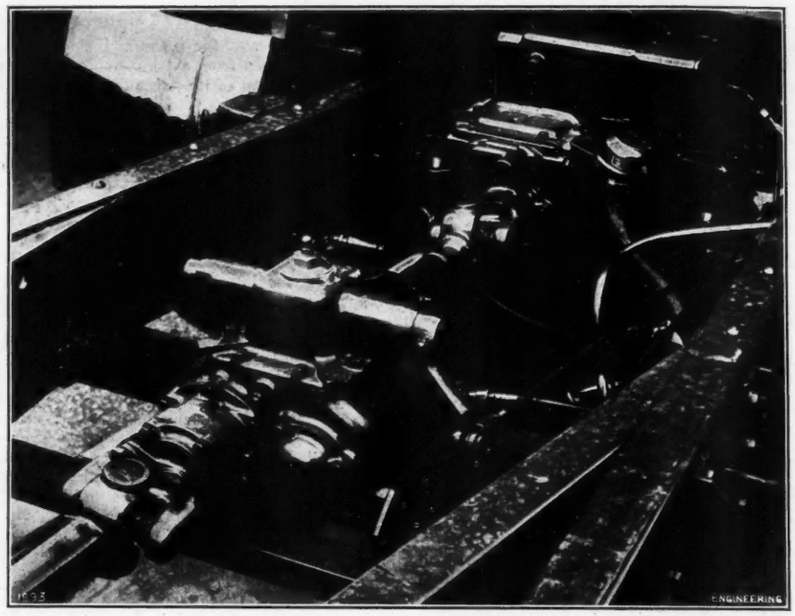
The following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2, Park-street, London, W.1, at the price quoted at the end of each paragraph.

Steel Butt-Welding Pipe Fittings.—A first revision of B.S. No. 1640, a specification covering steel butt-welding pipe fittings for the petroleum industry, has just been issued. The specification was first published in March, 1950, and it has been revised in the light of experience in its use. Moreover, opportunity has been taken to bring certain dimensions into line with those of the latest edition of the American Standards Association Specification B.16.9, entitled "Steel Butt-Welding Fittings." The British Standard specification applies to seamless (forged or cast) and fabricated carbon and alloy-steel butt-welding fittings and covers 45-deg. elbows, 90-deg. elbows (long and short radius), return bends (long and short radius), 90-deg. tangent elbows, equal tees, reducing tees, concentric reducers, eccentric reducers, caps and lap-joint stub ends. The specification provides for fittings of 1½ in. nominal size and upwards, but dimensions and tolerances are shown only for fittings up to and including 24 in. Each size of fitting is identified by the corresponding nominal pipe size. [Price 7*s.* 6*d.*, postage included.]

Unified Machine Screws and Machine Screw Nuts.—A new specification, B.S. No. 1981, covering Unified Machine Screws and Machine Screw Nuts, has been issued in response to a request from the Inter-Services Engineering Standards Co-ordinating Committee. After the specification for Unified screw threads (B.S. No. 1580) was completed and published in July, 1949, the Committee put forward a request for steps to be taken to secure similar agreement on the general dimensions of commonly used types of bolts, screws and nuts having Unified threads. As a result of discussions between the United Kingdon, the United States and Canada, agreement was reached on two series of bolts and nuts, and B.S. No. 1768, relating to Unified precision hexagon bolts, screws and nuts—normal series, and B.S. No. 1769, concerned with Unified black bolts, screws and nuts—heavy series, were published in September, 1951. The newly issued specification is complementary to B.S. Nos. 1768 and 1769 and provides, as they did, for screws having Unified threads, and heads selected from a range already standardised in the United States. While it is generally understood that the Unification of screw threads has been limited to sizes ¼ in. and upwards, provision has also been made in the new specification for a restricted selection of American Number sizes, namely, 4-40, 6-32, 8-32, 10-24 and 10-32, which are to be regarded as Unified for the purposes of attachment screws only. General dimensions and various requirements are given, in B.S. No. 1981, for countersunk, raised-countersunk, pan and raised-cheese head screws with slotted or recessed heads, small hexagon head screws, and precision and pressed nuts. The dimensions of appropriate washers are also included. [Price 6*s.*, postage included.]

OVER-DRIVE GEARBOX FOR HEAVY VEHICLES.

MORRIS COMMERCIAL CARS, LTD., BIRMINGHAM.



BOOKS RECEIVED.

Baudechnik-Archiv No. 9. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 14·50 D.M.]; and Lange, Maxwell and Springer, Limited, 242, Marylebone-road, London, N.W.1. [Price 25*s.* 5*d.*]

Erfahrungen mit Betonstrassen. By Professor Rudolf Dittrich. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 12 D.M.]; and Lange, Maxwell and Springer, Limited, 242, Marylebone-road, London, N.W.1. [Price 21*s.*]

Jahrbuch der Schiffbautechnischen Gesellschaft, 1952. Springer-Verlag, Reichpietschufer 20, Berlin W.35, Germany. [Price, 40 D.M.]

Sound Barrier: The Story of High-Speed Flight. By Neville Duke and Edward Lanchbery. Cassell and Company, Limited, 37-38, St. Andrew's-hill, Queen Victoria-street, London, E.C.4. [Price 8*s.* 6*d.* net.]

L'Aéronautique en 1953. *La Technique Moderne.* Special Number. Dunod, 92, Rue Bonaparte, Paris (6e). [Price 580 francs.]

United States National Bureau of Standards. Circular No. 542. *Graphs of the Compton Energy-Angle Relationship and the Klein-Nishina Formula from* 10 *Kev to* 500 *Mev.* By Ann T. Nelms. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 55 cents.]

Cornish Pumping Engines and Rotative Beam Engines. An Illustrated Survey. Second revised edition. The Secretary, Cornish Engines Preservation Society, Trevaunance-road, St. Agnes, Cornwall. [Price 5*s.* to members, 15*s.* to non-members.]

British Standard Locomotives. The Locomotive Publishing Company, Limited, 88, Horseferry-road, London, S.W.1. [Price 1*s.* 6*d.*]

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OVER-DRIVE GEARBOX FOR HEAVY VEHICLES.

Morris Commercial Cars, Limited, Adderley Park, Birmingham, 8, have introduced a two-speed over-drive type of gearbox which can be mounted on the chassis frame of heavy vehicles between the main gearbox and the rear axle, as shown above. It is controlled by a lever mounted near the hand-brake lever in the cab. By means of this gearbox all the main gearbox ratios can be stepped up, when conditions permit, thus reducing the engine revolutions and the load on the engine. Such units are said to be of particular advantage on a heavy 5-ton type of vehicle driven by a Diesel engine, which by the nature of its design requires that the maximum engine r.p.m. be restricted.

The over-drive gearbox contains a simple two-speed train of gears, using straight-tooth pinions in constant mesh. They run on ball and roller bearings and the lubrication is by the same method as that used for other types of boxes. The over-drive ratio is 1 to 1·24, and the complete box and fittings weigh 56 lb. The engagement and disengagement are carried out in the same manner as changing gear. The reduction in engine revolutions for any given road speed, is in the order of 19 per cent., giving a saving in the fuel being consumed of up to 10 per cent. and reduced engine wear and tear. A typical example is given by a long wheelbase vehicle which was fitted with 7·50 by 20 tyres. At 30 m.p.h., with a standard axle ratio of 6·714 : 1, its engine ran at 1,910 r.p.m. on direct drive and 1,541 r.p.m. on over-drive.

Trade Mission to North America.—Final arrangements for the tour of North America by a party consisting of Lord Bilsland, M.C., President of the Scottish Council (Development and Industry), Mr. R. A. Maclean, chairman of the committee responsible for the Scottish Industries Exhibition 1954, and Dr. Christopher Macrae, the exhibition committee's secretary, were made recently at a meeting of the executive committee of the Scottish Council, who are sponsoring the mission. The party is due to leave Scotland on October 31. Dr. Macrae described the object of the venture as being "to proclaim the Scottish Industries Exhibition 1954, and to sell Scottish goods." The mission would do its utmost, he said, to bring the maximum number of dollar buyers to the Kelvin Hall next autumn. It would endeavour to find further outlets for Scottish products and to persuade North American organisations to take advantage of the facilities offered by Scotland as a location for new factories.